How to Become a Competent Motorman

Livermore
AND
Williams

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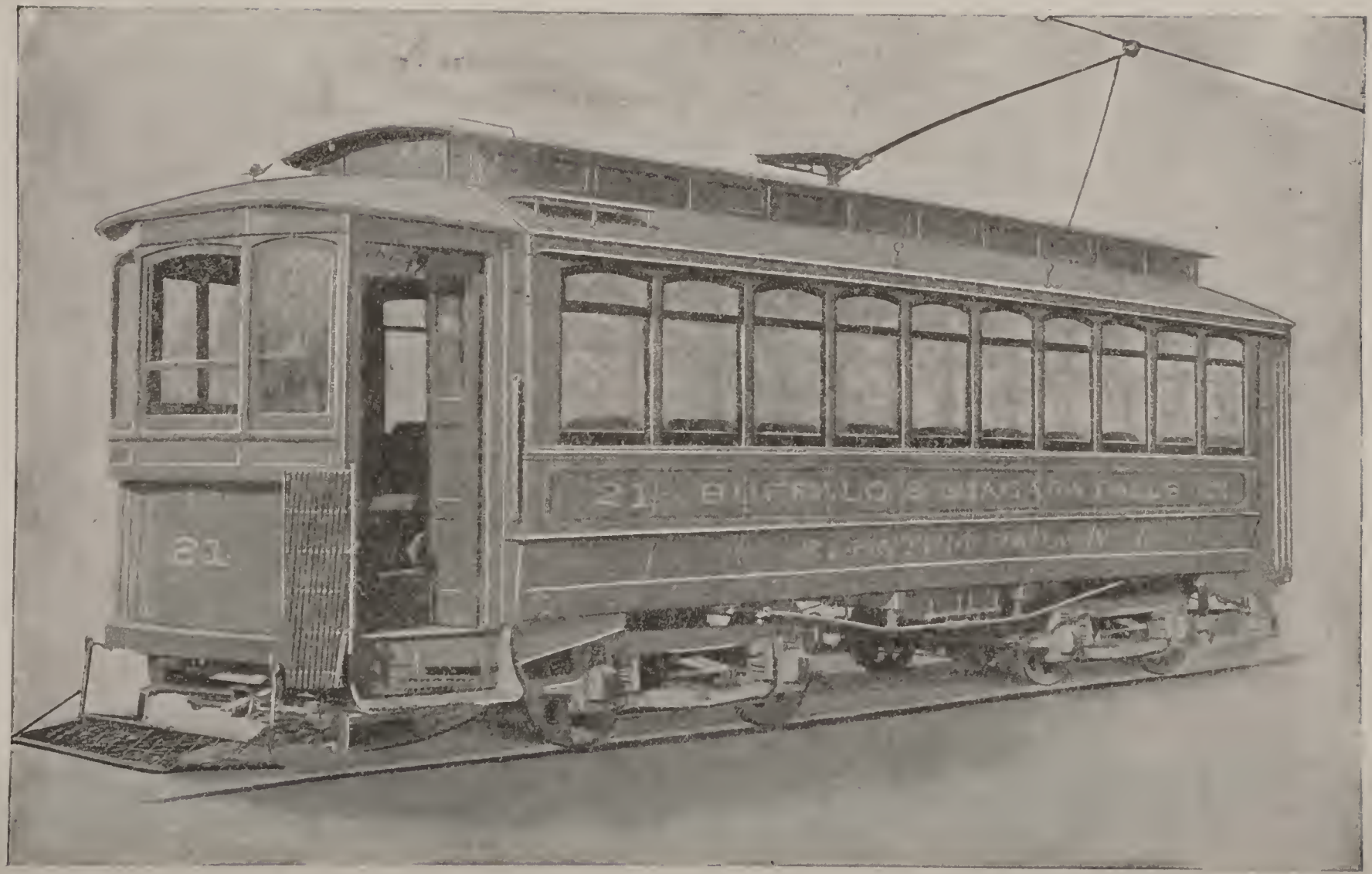

MODERN FOUR-MOTOR EQUIPMENT TROLLEY CAR

HOW TO BECOME A COMPETENT MOTORMAN

A PRACTICAL BOOK ON THE PROPER METHOD OF OPERATING A STREET RAILWAY MOTOR-CAR; WITH INSTRUCTIONS HOW TO OVERCOME TROUBLES ON THE ROAD

BY

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PREFACE

THIS book is addressed to motormen, and to those who desire to follow the calling of motormen. It is written by two practical men who have by actual experience learned just which things a competent motorman must know. Being written from the standpoint of the motorman by *practical men* is a guarantee that the style and contents are perfectly suited to the purpose of the book. The aim of the book is to enable any one to thoroughly understand the construction and operation of modern electric cars and locomotives. A motorman who thoroughly understands the machine with which he is working is in a position to save a lot of money for the company employing him, and it is the man who saves money for the company who is sure of his job and at the same time stands the best show of being advanced and promoted to the responsible and well-paid positions which always occur in large corporations. The manner in which a car is started and run makes a great difference in the amount of current that the car uses up, and also in the amount of time and money that have to be expended on repairing the car and keeping it in running order. Every time that a car is put into the shop for repairs, money is lost both in the repairing of the car and in its earnings, which are stopped while it is not running. When a car refuses to run for any reason, a well-informed motorman can make an investigation, find out the trouble, and in many cases make the nec-

essary repairs on the spot, thus keeping the car in operation and preventing further damage.

The position of the motorman is one of responsibility and dignity and is becoming more so every day. It is estimated that a hundred millions of dollars are spent in the building and development of electric railways in this country alone, every year. Steam roads are built only where for some cause or other electric roads cannot be built, and in cities and towns electric railways have entirely supplanted all other kinds. Besides this, the past year has seen the substitution of electricity for steam on one of the most important railroads in the United States, and among engineers it is freely predicted that this is only the beginning of a great change in that direction. As a result of all this, motormen will always be in demand. But as the size and value of the cars becomes greater and it becomes more and more difficult to operate them properly, there will be a weeding out of the ignorant and incompetent people and only the skilful and well-informed men will be wanted. The motorman is responsible for the car and the lives of his passengers and also for the lives of people crossing streets in front of his car, and it is for this reason that some states require that every man who wishes to run a car must pass an examination to show that he is fit to take this responsibility. More states are passing this law all the time and soon it will be impossible to run a car anywhere in this country without first passing this examination. The contents of this book, if mastered, will enable any one to pass any examination that may be given.

Great attention has been given to detailed descriptions of the different car equipments in use throughout the country. The motorman should read carefully the description of the

car that he is operating and learn all about it; the descriptions of other types of cars are of less importance, but should be understood by all up-to-date and ambitious motormen. Wherever possible the well-known and tested method of *questions and answers* has been used, but descriptions have been used throughout wherever needed. A great deal of space has been devoted to *troubles* and *accidents*, each part of the car being treated separately. Air-brakes have been treated in some detail, but as there are already many very complete books on this subject it is considered more valuable to devote most of the space to electrical matters. One of the authors is at present engaged in locating and correcting *troubles* on the cars of one of the most important electric railway systems in the world, and feels that he knows what troubles are likely to occur.

The book is simply written for the use of motormen who do not find time to study algebra and the higher mathematics so there are no mathematical signs in the book. The introductory chapter supplies the elements of electricity that will be needed to understand the book, but it is earnestly recommended that all motormen desiring further information read Swoope's "Lessons in Practical Electricity" which treats the subject very simply and thoroughly. The chapter on the prevention of accidents will be found of great value to every one.

In conclusion the authors wish to express their thanks to the Westinghouse Co. and General Electric Co. for permission to use cuts and information concerning their products.

Jas. R. Williams.
V. B. Livermore.

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COMPETENT MOTORMEN

In order to understand clearly what takes place in an electric motor when the current is turned on, it is necessary that we devote a few moments to a definition and consideration of the terms and phrases commonly used in electrical practice.

For all practical purposes it might be said that electricity flows in copper and other metals very much as water does in pipes. The difference is that while the water-pipe is hollow, the electrical conductor is solid, but if we regard it as carrying the current in the same way as a wick carries oil, the comparison becomes clear.

In the flow of water there are several things to consider, viz., — the force or pressure, generally measured in pounds per square inch, the quantity of water flowing, generally measured in gallons or in cubic feet, and the resistance of the pipe or faucet, which, in conjunction with the pressure, determines the quantity of flow.

In two separate water-pipe systems, if the pressures and the resistances of the pipes and faucets be the same in each, the quantities of flow will be the same. Any increase in pressure will result in more flow, and any increase in resistance will result in less flow, and vice versa.

In electricity we meet with almost precisely the same conditions. There is the pressure, voltage, or electro-motive force

(e.m.f.) measured in volts, the resistance measured in ohms., and the flow measured in amperes.

Conductors are substances which conduct or carry electricity. All metals are conductors, though some are better than others. By a good conductor is meant one which has a low resistance or which would carry a large amount of current at a given pressure. A two-inch pipe carries more water than a one-inch pipe; a copper wire carries more current than an iron wire. Silver, copper, aluminum, and iron are the conductors which come into use in everyday practice. Silver is the best conductor, but owing to its high cost it is used only in delicate instruments where its high power of conducting is more important than considerations of cost. Next comes copper; this is generally used in all electrical work excepting where iron can be substituted. But as copper is a much better conductor than iron or steel (about eight times better) the iron conductor would have to be eight times as large to carry the same current. It is only in places where size does not count, as in third rails, that iron is used. After copper comes aluminum. This is used where weight is a consideration. It is only half as good a conductor as copper and therefore has to be twice as large for the same current, but it is only about one sixth as heavy as copper, so that a conductor of aluminum, though twice as thick, would be only about one third as heavy as one of copper of the same current-carrying capacity.

Insulators are subtances which do not carry electricity. Ebonite, glass, mica, paper, paraffine, shellac, wood, cotton, silk, and oil are insulators. Where two wires have to run side by side in a small space and are crowded together, but where the current must not leak from one to the other, each must be

wrapped in an insulator covering. These are called insulated wires. Where a wire is supported on a pole, it is insulated by being carried on a glass insulator which will not carry the current from the wire to the pin.

Electricity has two effects when flowing in a wire, viz., heating and magnetism. Whenever a current of electricity

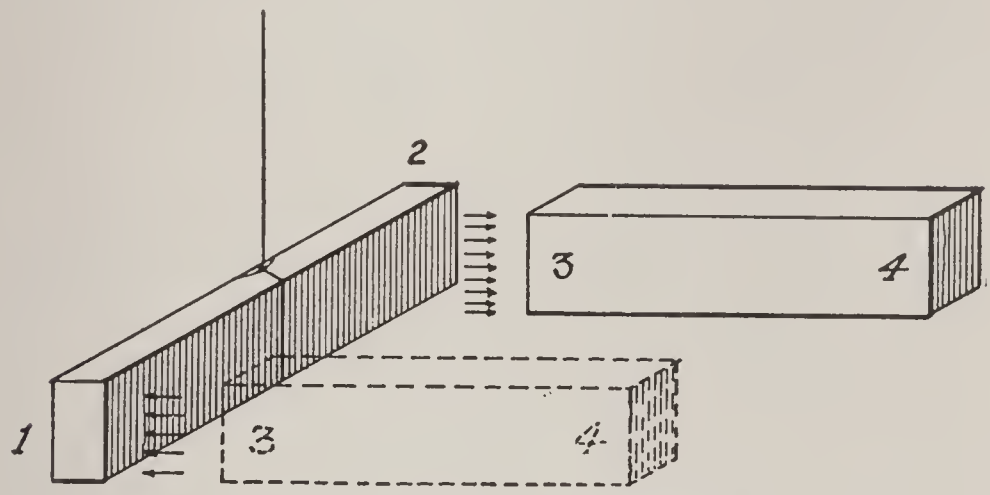


FIG. 1.—Magnet. Illustrations.

flows in a conductor, it heats that conductor. If the conductor is small enough the heat is very intense, as in the incandescent lamp or the car heater.

If a piece of iron has some insulated wire coiled around it, and a current is passed through the wire, the iron will be a strong magnet while the current flows, but will lose its magnetism as soon as the current is turned off.

A magnet is a piece of iron or steel which has the property of attracting other pieces of iron or steel. The two ends of a magnet are different. They will both attract iron, but if one end of a second magnet is brought near an end of the first one suspended by a string at the middle (see figure) the following facts will be noted: If we call the ends of the first magnet

No. 1 and No. 2, and the ends of the second magnet No. 3 and No. 4, then if No. 3 is brought near to No. 2 they will attract each other, but if No. 3 be brought near to No. 1 they will repel each other. Also No. 4 will attract No. 1 but will repel No. 2. This shows that there must be some difference between the ends of the magnets or they would act alike. This attraction and repulsion between magnets is the principle on which electric motors are built. In fact, the electric motor consists of a stationary magnet or "field," and a movable magnet, or "armature," attached to a shaft or axle. The field and armature are so arranged that they cannot touch each other, though the armature can revolve very near the field. The moving magnet is drawn to the fixed magnet, and just as it arrives the current is turned off so that it flies past. As soon as it passes the center of the field the current is turned on again in the opposite direction so that they now repel each other. And so on, as long as the current flows, the movable armature is kept revolving. This turns the shaft and the shaft turns the car axle.

The connections of the motor used in railway practice generally, are shown in the accompanying diagram (Fig. 2). This is the connection scheme for the "series" motor. This is called a series motor because the fields and armature are connected in *series*, which means that the current passes through the armature and fields one after the other. There are other kinds of motors, but as the series motor is practically the only one used on railways in this country, it alone will be considered. The current enters at *a*, passes around the fields, *F*, F′, making them magnets, then to the brush *b* which touches the commutator *C*, then through the armature *A*, back to the

commutator where the brush *c* touches it, and out at *D*. This simple diagram is for a motor having only two poles, but if there are four or more poles the scheme of connections is the same.

Railway motors are of the box type, that is, they are completely enclosed in a cast-iron box which is so arranged

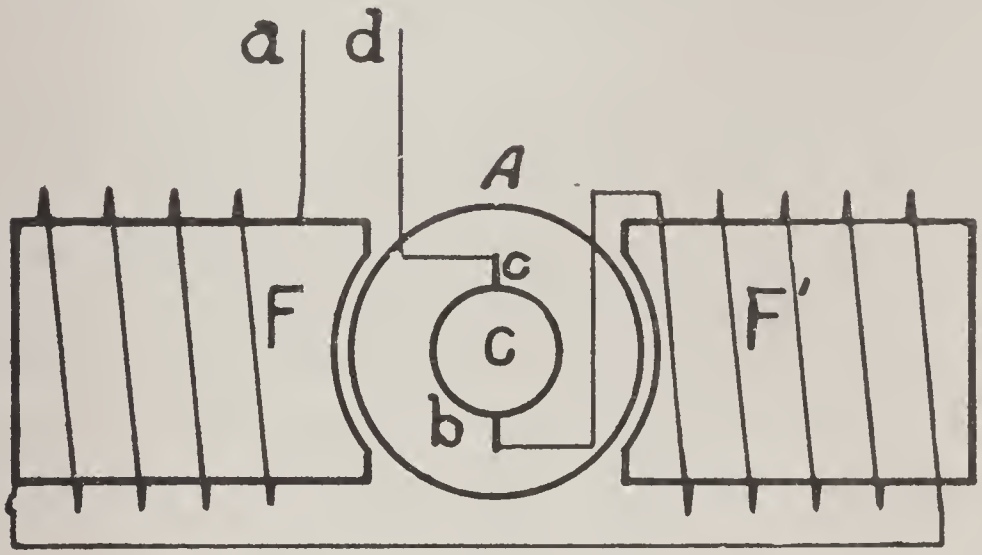


FIG. 2.—Motor Diagram, Simple Method.

as to be part of the motor. The reason for this is that water and mud which would greatly injure the motor are thus kept out.

Electric currents for railway purposes are generated in a machine called a dynamo. The dynamo is very much like a large motor in construction. It is driven by a steam engine and gives out a current of electricity. The current flows out of the machine at the positive or (+) end through the machines that are being driven, and back to the dynamo which it enters at the negative or (—) end. The path that the current follows, made up of the dynamo, the trolley wire, the car wiring and

motor, the track return circuit to the dynamo, is known as the *circuit*, also any path that a current follows is known as a circuit. For instance, the wiring of a car is known as the car circuit, and the path that the current takes within the armature of a motor is known as the armature circuit.

The word *equipment* is frequently used to denote the circuit of the car, including the wiring, the motors, the resistances, the lights, and all of the other special parts that the current passes through.

Wherever current flows in a piece of machinery, it must naturally enter at some point and leave at another. It is customary to call that point at which it enters, the positive end, and it is generally denoted by the plus sign (+); that point at which the current leaves the machine or circuit is called the negative end and is denoted by the minus sign (—), excepting in the case of the dynamos, where it leaves at the (+) end and enters at the (—) end.

A *short circuit* or *ground* occurs when, through some accident, the insulation on a wire becomes burnt or otherwise destroyed, and the enclosed wire touches another wire or some metal part of the machine. The current will then follow the shortest path to the negative point instead of following the regular circuit as it would have to do if the insulation were perfect. This is why it is called a *short circuit*. As the negative point often connects with the ground or earth, the short circuit is sometimes called a *ground*.

An *open circuit* occurs where, through some accident, the conductor has become parted. The circuit is then destroyed or *open* and the current cannot pass. Open circuits are often caused by the wires' being burnt off owing to the carrying of

too great a current, or to the fact that something has fallen on the wire, cutting it off.

There are three general modes of connecting up electric circuits which are in common use and which it is necessary to thoroughly understand. These are shown in Fig. 3. At *a* is shown what is termed a *series* connection. This means that the current enters the circuit (which here consist of lamps

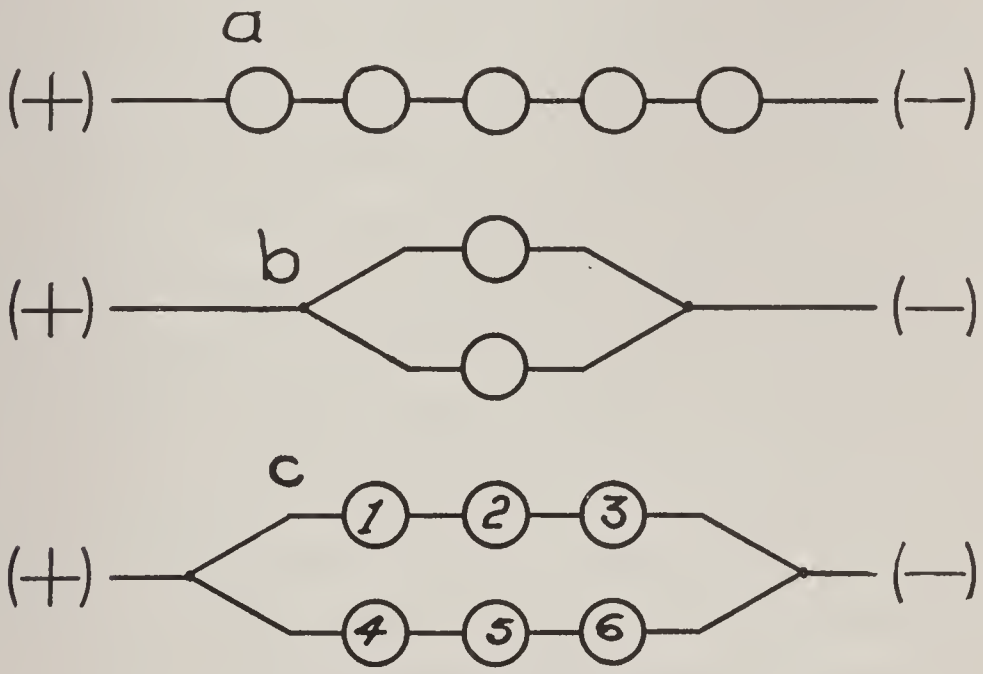


Fig. 3. — Circuit Diagram.

denoted by the small circles) at the (+) end and flows through one lamp after another till it reaches the (—) end of the circuit. At *b* is shown a *parallel* circuit. The current enters at the (+) end, splits at the point where the two wires connect with the positive wire, and flows through the two lamps at the same time; that is, part of the current flows through each, joining again in the negative wire. At *c* is shown a *series-parallel* circuit. The two lamps marked 1, 2, and 3 are a series, which we shall call series No. 1; the two lamps 4, 5, and 6 are another series which we shall

call series No. 2; now these two series are each a circuit, and the two circuits are in parallel. The current flows in at the (+) end, divides into two parts, which flow in the two circuits 1 and 2, at the same time and then come together at the (—) end. There may be more than two circuits in parallel in *b* and in *c*. Only two are shown here as being simpler to understand, but where there are more circuits the principle is precisely the same.

Where a current splits, as at *b* and *c*, and part of the current flows through one circuit and part through the other, the word *shunt* is frequently used to describe one of the paths. For instance, we may say in the above case (*c*) that part of the current is *shunted* through circuit No. 2. This is generally done when one of the circuits is much larger than the other, and takes more current; then the smaller circuit which takes the smaller amount of current is called a *shunt*.

Air is, generally speaking, a very good insulator, and bare wires which are separated by a gap of dry air are generally pretty well insulated from each other. If the pressure or voltage between the wires is very high, and the space is very small, then it might happen that the current will *jump* the gap and flow across in the air. This is rare and happens only with the highest pressure currents. On the other hand, if the two conductors are brought together so that current flows, and then separates, the current will continue to flow in the gap between the wires till the gap gets too long for the current. If the wires are separated just a small amount, the current will continue to flow steadily, giving out great heat and light. This is the principle of the common arc lamp and the flame which results is called the *arc*. In the arc lamp the two wires end in

sticks of carbon which are brought together for an instant until current flows; they are then separated about one half an inch and the current continues to flow in the gap, giving out a great amount of light. If metallic wires were used they would melt and run, but carbon burns very slowly and does not melt at all, so it lasts much longer than any metal would. In electric car switches, and in fact in all switches, the same thing happens when the switch is pulled out. As the two parts of the switch are separated to break the circuit, the current forms an arc which would burn up the switch if it were allowed to continue. In small switches the arc is broken by pulling the two parts far apart so that the arc cannot continue, but in motor cars where the amount of current may be very great, the arc is often so large that it would do great damage in a short time even, and especially if it is used a great many times per day. It is therefore necessary to provide some means of destroying the arc or *blowing* it, as it is called. It has been found that the magnet will attract the electric arc just as it will iron, so that if a very strong magnet is placed in a position near the switch, it will pull the arc away from the switch points as soon as it is formed. The magnet generally provided is an electro magnet or one which depends for its magnetism on the current. It is called a *blow-out coil.*

Even with the blow-out coil, the arc is very hot and would burn anything near it if the switch were not protected by being placed inside a large fireproof box. The boxes are so large that if they were placed inside the car controller, it would take up the whole of the platform or cab, and be very clumsy, so the main switches are placed in some convenient position under the car and they are worked automatically, through a

relay. The relay is nothing more nor less than a pilot valve. The motorman has a small switch in the controller case, which turns on a small amount of current which does not make much of an arc. This small current operates a *contactor*. The contactor is a large automatic switch, placed out of the way under the car, and it turns on the current into the motors.

It has already been pointed out that the electric current heats any conductor in which it flows. The amount of heat depends on the amount of current, and if the current is great enough, it will burn the conductor up, and destroy it. In case of a short circuit the amount of current which would rush in might be enough to burn and ruin the car circuit and motors, so some means must be provided against this. For this purpose the *fuse* and *circuit-breaker* have been introduced. The fuse is a thin strip of some metal easily melted, generally lead or some alloy of lead, which forms part of the circuit. If the current gets too great, the lead will melt and open the circuit, thus shutting off the current entirely. It is placed in a fireproof box so that when it *blows* it can do no damage. The *circuit-breaker* is simply a switch with a spring holding it in place, and an elector-magnet trying to pull it out. The strength of the spring and the magnet are so arranged that the spring is stronger for all amounts of current that are safe, but as soon as the current becomes too great, the electro-magnet becomes stronger than the spring and pulls the switch opening the circuit.

ELECTRICAL UNIT

The primary units of electricity are the volt, ampere, ohm, and watt.

VOLT

The volt is the unit of pressure or the pressure required to press one ampere through a resistance of one ohm.

The voltage or pressure is also spoken of as the electromotive force and generally written e.m.f.

AMPERE

The ampere is the unit of current or flow; it is the amount of current which will flow in a circuit of one ohm's resistance, with a pressure of one volt.

OHM

The ohm is the unit of resistance; it is the amount of resistance through which one ampere of current will flow with one volt of pressure.

WATT

The watt is the electrical unit of power, and is equal to the rate at which work is done by a current. 746 watts equal one horse-power.

The watts in any circuit are equal to the volts times the amperes.

BRIEF DESCRIPTION OF A STREET RAILWAY MOTOR

The main parts of a street railway motor are a field magnet, which is stationary, and a revolving armature. The field

magnet is composed of an iron or a steel casting, which has a certain quantity of insulated wire wound around it. The electricity passing through this wire or field coil magnetizes the iron, creating magnetic poles. The revolving armature is composed of thin disks of soft sheet iron, firmly bolted together and fitted on a shaft; this is the armature core. This is dressed up in the machine shop, and wound with a certain number of turns of insulated wire, which are connected together, so as to form one continuous wire, passing lengthwise around the core. Before the armature is wound, the core is thoroughly insulated with the best of insulating material; this is a very important factor in the construction of an armature, as defective insulation would cause the windings to ground on the core, in which case the armature would have to be stripped and re-wound again. The shaft upon which the armature is built furnishes both a support and means of transmitting the power of the armature to the wheels, by means of its pinion meshing with a gear on the truck axle. The winding of the armature is the most vital part, as it is in this, as in the field

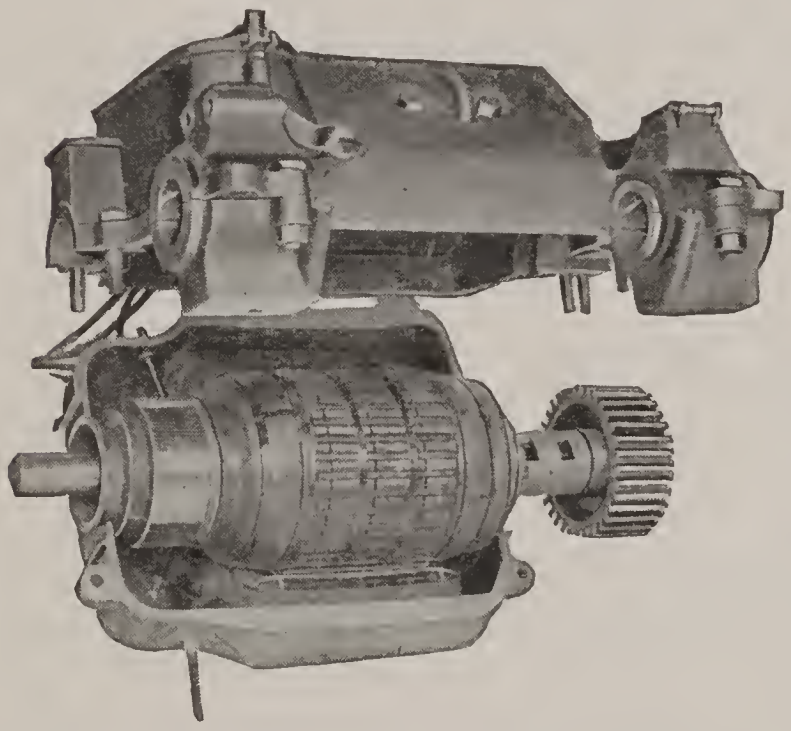


FIG. 4. — No. 8,760. G. E. 57—50 H. P. Motor — Open.

magnets, that the current sets up the force that causes the motion in the wheels of the car. When a wire carrying a current is brought in front of a pole of a magnet a force is experienced which tends to drive the wire sideways away from the magnet, and this is what takes place in an electric motor. When the windings of an armature, carrying current, come in front of a pole-piece of the field magnet they are forced away and the armature is kept revolving as long as the current flows. On the end of the armature shaft is a pinion, which meshes into a large gear wheel keyed on to the truck axle, and in this way an electric car is propelled.

THE RHEOSTAT SYSTEM OF CONTROL

The rheostat is a device for controlling the electric current and for diminishing its flow. The office of a rheostat as used to start up an electric motor is similar to that of a steam valve on a steam engine; that is, it is simply used to give a gradual admittance of the current to the motor, and is usually cut entirely out of circuit as soon as the motors reach their maximum speed. The necessity for the rheostat can be explained by carrying the analogy of the steam valve a little farther. The construction of the motor is such that when it is at rest the full admittance of the current would destroy it, just as the full admittance of the steam to the steam-engine cylinder would be almost sure to strain or break some of its parts.

Different manufacturers vary in their method of mounting and connecting rheostats in circuit, but the principle in all cases is the same. A rheostat is also known as a resistance.

There are many styles built by different electrical com-

panies; each having its advantages. Those in use at the present day are the Thomson-Houston, Westinghouse, General Electric and Lundie Resistances.

T. H. RHEOSTAT SYSTEM

The Thomson-Houston rheostat is composed of an iron frame, semicircular in shape and having a recess for inserting the resistance plates. The circuit is closed by a rheostat arm and sliding contact shoe. The plates are in series connection, terminating with the contact plate terminal, to which is attached the field end wire of motor circuit. Also in advance of this terminal a second contact plate is in connection with the field loop wire of motor circuit.

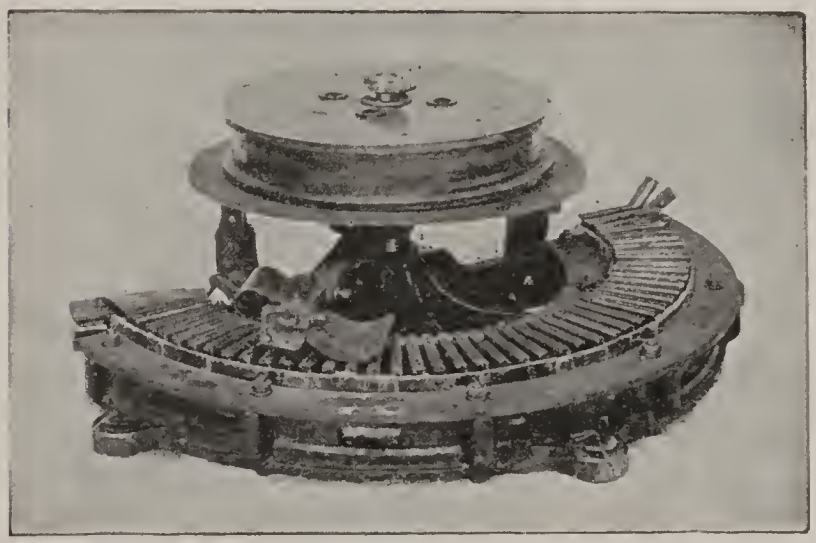


Fig. 5. — T. H. Rheostat Type 51 D.

The rheostat spindle and drum are secured in a vulcabestor bushing, which is clamped to the center of this semicircular device. A rheostat arm having at its end a sliding contact shoe for closing the circuit, with resistance plate of rheostat. The arm is constructed so as to raise or lower for adjustment; it being provided with a screw thread.

The rheostat arm is propelled or moved around by what is known as the rheostat drum or pulley. This drum is composed of wood usually, on the under side of which is attached

a U-shaped casting, which is extended so as to secure the rheostat arm for operation.

The rheostat is controlled by what is known as the rheostat cables, which are attached to the rheostat drum and secured by a staple. This cable has one complete turn around the drum, and the ends are attached to sprocket chains. The other part of the cable is called the floating cable, the ends are attached to the opposite ends of the sprocket chains. The chain is operated by the sprocket wheel, the cogs of which mesh with the chain. The sprocket wheel is operated by a spindle which extends from the top to the bottom of the controller stand, the spindle being operated by a crank handle.

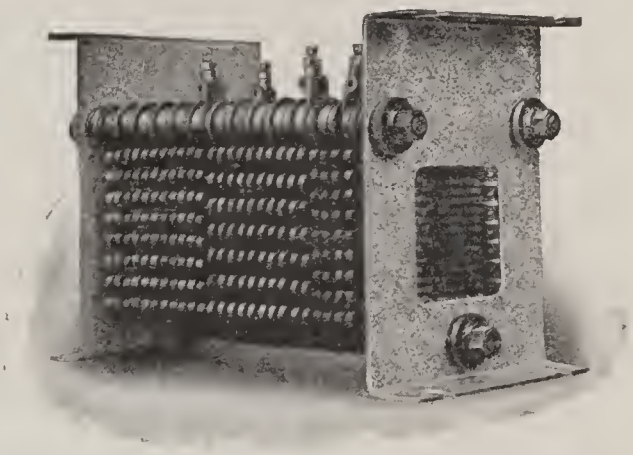


Fig. 6. — Grid Diverter for Railway Equipments.

The rheostat just described was the first type of resistance used in connection with street railways motors in the earlier days of electric railways.

The rheostats of the present day are of a different type and build. They are composed of long strips of annealed band iron which are built up in layers, each layer being insulated from the others by asbestos or mica. When formed this is known as a panel of resistance. The number of panels usually placed in a rheostat frame is six, each one having a certain amount of resistance. They are placed in series connection with terminal binding-posts attached for connecting rheostatic wires from the controller which cut in certain sections, each represented by its individual wire.

Another type of modern rehostats is known as the Grid type; the panels are composed of cast-iron grids which are cast in a zigzag shape, so as to form a continuous circuit, having as nearly as possible a specified resistance. The grids or panels are mounted on two iron bars, having a mica insulation. Binding-posts are attached at certain intervals for rheostatic lead wire connections which are attached to the controller.

CONTROLLERS

The controller is probably the most important and certainly the most complicated part of an electric car equipment.

Its position is always at the outer end of the car platform and through its mechanism the current is led to the motors and resistance, thereby producing the several combinations to determine the speed of the car. In stating that the position of the controller is always at the platform end, I mean at the present time, as I remember some years ago when the Vanderpoele system was in use that the motor and starting-box were inside of the car at about the center. The car was propelled by means of a sprocket chain running from a sprocket wheel on the armature shaft to another sprocket wheel on the car axle. There have been two distinct types or methods of control which have been put into use in connection with the propulsion of cars. The first that was used to any extent was that of the Sprague system. In this system the field coils were divided into several sections and these sections, together with the armatures, formed the several steps or combinations which were to vary the speed. The second form is that in which the field and armature circuits remain unchanged, while a heavy resistance is placed in circuit with them. The resistance method of

control is the simplest of any which has ever been used, and by it an almost perfect control over the speed of the car is gotten. By this method the car can be started and its speed increased up to the limit very gradually, without any perceptible jar.

There are many types of controllers in use at the present date, but the universal types are of the General Electric and Westinghouse build.

G. E. CONTROLLER .

The G. E. controller consists of an iron frame with a cover. Within are placed two cylinders, and also contact wipers or fingers for operation. The large or main cylinder closes the connection with the motor and rheostatic combinations. The small or reverse cylinder closes the connections with the motor circuit.

Of the many types of controllers which are manufactured by the General Electric Company, the types known as K, K–1, K–2, K–10, and K–11 are the ones generally used by street railways, and, at the present date, the two latter types, K–10 and K–11, are generally adopted. The types K and K–1 are identical except in the build of the connection board, the difference being that in the type K each lead wire of cable is secured to binding-post of connection board by means of a crow-foot terminal, and secured to the binding-post by a nut; while in type K–1 the connection board is equipped with socket binding-posts, and each lead of cable is secured in its socket by means of a set-screw.

WESTINGHOUSE CONTROLLER

The Westinghouse Company has made many different forms of controllers while adhering to the same general form of motor. The earlier forms of Westinghouse controllers are

named in alphabetical order, from A to G inclusive. Controllers B, C, and E were put out with their earlier types of motors, which were arranged for parallel running. The type G was first adapted for series parallel running, but was afterwards superseded by type 14. This later was followed by the type 28–A controller. The most commonly used controllers at present, with series parallel motors, are No. 14 and No. 28–A. A description of type No. 14 follows:

Upon opening the controller case you will observe eleven contact wipers or fingers at the left of the controller, also the twelve main cable terminals at the bottom, and the two cut-out plugs near the center and at the right-hand side. The reversing switch differs from the General Electric type. It is the form of a flat disk of slate or porcelain, and is located immediately under the heavy brass top of the controller case. With this controller there are six speed points. The first two have resistance in series with both motors in a series. At the third point both motors are in series with all of resistance cut out; at the fourth and fifth positions the motors are in parallel, each having resistance in its circuit, and at the sixth position the motors are in parallel with all resistance cut out. The controller known as the 28–A is quite similar to the type 14, differing from it only in its mechanical construction. The method of reversing is the same excepting that the handle is placed at the top of the controller instead of at the side as in the type No. 14. The cylinder is not arranged to swing open as in type 14, but may be readily taken out to make repairs. The main cable terminals are distributed at the sides and bottom of the controller.

The cut-outs also are slightly different in form. With the

type 14 controller, when motor No. 1 is cut out, motor No. 2 will not start until the controller handle is thrown on to the fourth position, and in order to operate your car notches Nos. 4, 5, and 6 are used. When motor No. 2 is cut out, your car will take power on the 1st, 2d, and 3d positions. With type 28–A controller, no matter which motor is cut out of circuit, the remaining motor is operated on notches 1, 2, 3, and 4, the controller being locked from passing beyond this.

CURTIS CONTROLLER

The Curtis controller is a series parallel controller, and in general principles is the same as all others of the same class. On the Form A controllers the running notches are 3 and 7, and on the Form B they are 3 and 5. The first three points are series points, and the others are parallel points. This controller has no blow-out magnet coil, as the General Electric controllers have, but has arc deflectors between each two wipers or contact fingers. Neither has it motor cut-outs for cutting out a defective motor, and in case of a defective motor the motor leads have to be disconnected at the motor, the same as the W. P.–50 T. H.

This controller has no connection board at the bottom of the controller, the connections being made on either side, the armature and field wires to the right side and the resistance wires, trolley and ground wires connect on the left side to the wiper board. The setting of the reverse handle indicates the direction in which the car will move, and great care should be taken that the reverse handle is not pulled back or moved in any way while the power is on, as it would greatly injure the controller, and it would be plain to see how the damage was

done on opening the controller case; besides, if you wanted to make a quick stop, this way is not reliable, as the fuse would surely blow if you pulled over the reverse lever with the power on. When it becomes necessary to reverse the car, to stop in case of an emergency, first throw off the power, then pull the reverse lever and apply the power slowly, and then your fuse is not as liable to blow. An arrangement of cam roller and wheel plainly marks to the touch the successive stops, so that the motorman does not have to watch the dial plate, but can be on the lookout to see that the track is clear ahead. As before stated, to cut out one motor, the connections have to be disconnected at the motor, and you will find that the car will not start until the handle is moved to the fourth position. This can be remedied, however, by closing the field and armature circuits. After disconnecting the defective motor, connect together the two brush wires and then connect together the two field wires. The wires that you are to connect together are the *wires coming out of the body of the car, and not the wires coming out of the motor.* This will give you power on the first three notches, and the controller must not be operated beyond that position. You should exercise great care in the handling of these controllers, and be sure to work them on the notches and not half-way between.

WALKER CONTROLLER

In this controller the arc is broken by a cylinder placed in the controller for that purpose. The circuit is broken at twenty-eight points, and is supposed to render the most severe arc entirely harmless. Another feature consists in entirely separating the operation of breaking the circuit from the con-

trolling cylinder. The controller consists of two cylinders. The controlling cylinder proper is used to make the different combinations required to obtain the proper regulation of speeds of the car for acceleration. The second cylinder is used for the breaking of the circuit whenever this is required. The arc-breaking cylinder which is to the left of the controlling cylinder has its circuit so arranged that the main current passes first through it before going to the controlling cylinder. The mechanism of the arc-breaking cylinder is so arranged that with a slight movement of the controller handle backward, the circuit is completely opened, leaving the controlling cylinder entirely dead. The controller cannot be closed again until the controlling handle has been brought back to the off position. After the circuit has been opened by the slight backward movement of the controlling handle, the controlling cylinder can be moved backward and forward into any position with-

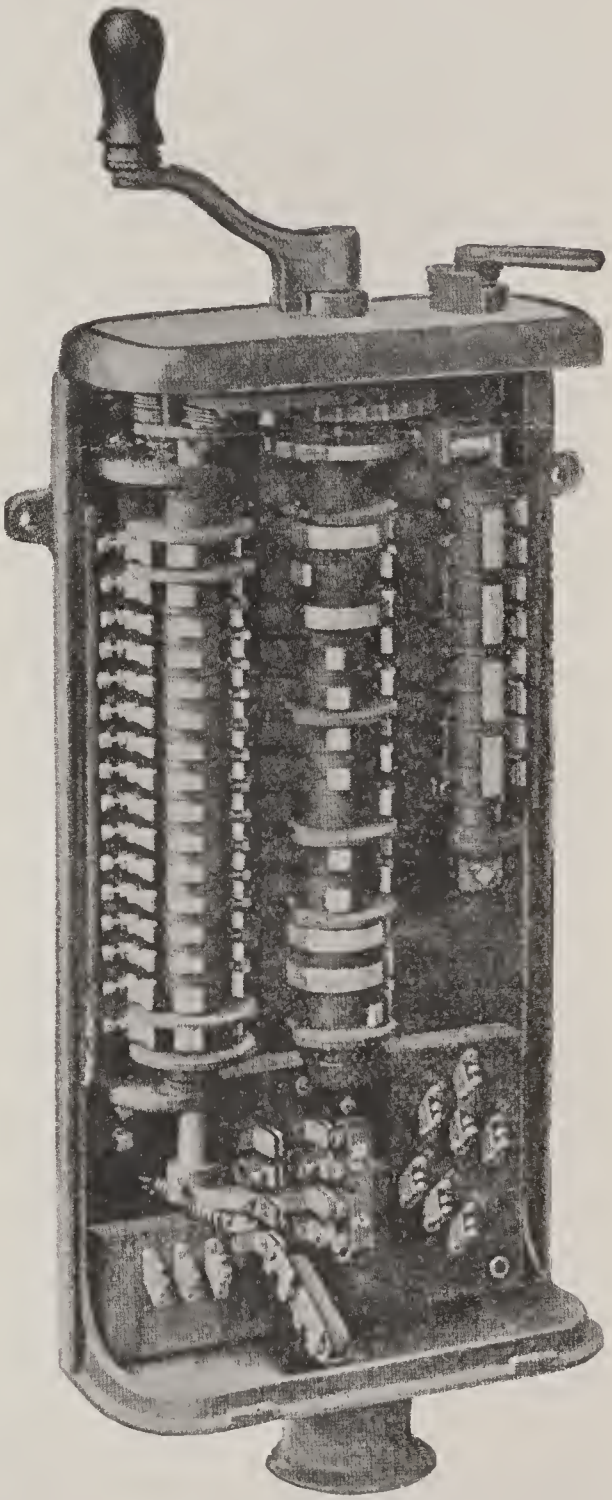


FIG. 7. — Walker Controller, showing arc-breaking cylinder at left; also showing No. 1 motor cut-out.

out producing any effect, and it is absolutely necessary to go back to the off position before the circuit can be closed. This feature makes it impossible to drop back from one notch to another in such a way as to put in or take out resistance in the circuit. A slight movement of the handle backwards cuts off the current from the car, thus leaving the motorman free to attend to his brake. There is also an interlocking device whereby the pawl that indicates the various running positions acts at the same time as a lock between the controlling cylinder and reverse. The controlling cylinder is locked when the reverse is in any other position than forward or backward, and the reverse is locked except when the controlling cylinder is at the off position. The motor cut-out switches are in each controller, and a peculiar feature is, that in cutting out a motor on No. 1 end, it has to be cut out on the No. 2 end also. In cutting out a defective motor, cut it out in both controllers.

CIRCUITS OF G. E. CONTROLLERS

The following is the course of the current in a G. E. type K or K–1 controller, with two motors, in a series parallel connection with shunt method of operation:

First Position

The current passes from the trolley wire to the trolley wheel, through trolley pole to trolley stand, then through wire leading to No. 1 overhead switch (M. M. switch). When switch is closed the current passes through the wire leading to No. 2 overhead switch (M. M. switch); and when switch is closed the current passes through wire leading to and connecting with

the fuse box (cut-out box), leaving same and passing through wire which connects with lightning arrester. When a T. H. lightning arrester is in circuit the current passes in at a point marked A, passing through blow-out magnet coil, leaving at a point marked B; then passing through a wire connecting with the wire in cable marked T (meaning trolley). The current passes through this wire, which connects with terminals marked T on connection board of each controller, and also in connection with each blow-out magnet coil of controller. The current then passes through blow-out magnet coil, when in operation, and then passes through a wire connecting with the top contact wiper or finger of each controller. When controller cylinder is thrown to the first position the current passes through wire marked R–1, which is the first wire connecting with the rheostat or resistance, leaving the rheostatic circuit through wire marked R–3, connecting with terminal marked R–3 on connection board of each controller — that connecting with wire marked No. 19, which is the main circuit wire of No. 1 motor's entire circuit; that connecting with the bottom contact wiper or finger of reverse switch or reverse cylinder. When reversing switch or cylinder is thrown ahead for the forward motion of the car the current passes to and leaves at the second contact wiper upon the reverse switch, passing through wire marked A–1, which is the wire connecting with the brush-holder of No. 1 motor's armature. The current then passes through the armature, leaving at opposite brush-holder, passing through wire marked AA–1, which connects with the third contact wiper upon reverse switch — the current leaving at the fourth contact wiper upon reverse switch then passing through wire marked F–1, which is the wire connecting with the field cir-

cuit of No. 1 motor, which is composed of one, two, or four fields, leaving the same and passing through wire marked E–1, which is the ground end wire of No. 1 motor's entire circuit; that leading to and connecting with the center bar of No. 1 motor cut-out switch. The current then passes through wire and connects with the contact wipers marked E–1, and then in connection with (through) cylinder to wire marked No. 15, which is the main circuit wire of No. 2 motor's entire connection; then connecting with the fifth contact wiper upon reverse switch, the current leaving at the sixth contact wiper upon the reverse switch, passing through wire marked A–2, which is the wire connecting with the brush-holder of No. 2 motor's armature circuit; the current then passes through armature circuit; leaving at opposite brush-holder, passing through wire marked AA–2, which connects with the seventh contact wiper upon reverse switch, the current leaving at the eighth contact wiper upon the reverse switch, then passing through wire marked F–2, which is the wire connecting with the field circuit of No. 2 motor, which is composed of one, two or four field coils, leaving same, and passing through wire marked E–2, which is the ground end wire of No. 2 motor's entire connection, that leading to and connecting with the main ground wire marked G at motor. The above is the complete circuit of two motors, in series, in connection with G. E. controller, type K. or K–1, on first position.

Second Position

When using the second position the two motors are still held in series, the circuit being the same as on the first position, but with this exception, that instead of the current passing

through wire R–1, it passes through wire marked R–2, which leads to and connects with the rheostatic circuit. On this position, a part of the resistance is cut out, leaving about one-half of the number of panels of resistance in connection with motor circuit which allows an increased speed of motors by an increase of current to motor terminals.

Third Position

When using the third position the two motors are still held in series, the circuit being the same as on the first and second positions, but with this exception, that there is no rheostatic connection whatever with motor circuit, the current being direct to motor terminals, which allows a still greater speed of motors than in the second position through an increase of current to motor terminals.

Fourth Position

When using the fourth position the two motors are still held in series, as on the preceding positions, and without exterior resistance, but with this exception, that the field circuits are shunted, the current shunted from No. 1 motor's field circuit is carried to a ground through No. 2 motor's armature circuit, the current shunted from No. 2 motor's field circuit is carried to ground through the main ground wire terminal in the controller; the shunting of the field circuit of motors Nos. 1 and 2 decreases the field strength which allows an increased current at armature terminals, which gives an added increase of speed to the armatures.

Fifth Position

When using the fifth position the two motors are placed in parallel or multiple, with about one-half of rheostatic panels of resistance in connection with same, the current passing to rheostat through wire marked R–2. On this position the wire marked E–1, which is ground end wire of No. 1 motor's entire connection, is placed in connection by the controlling cylinder to main ground wire in controller. The circuit of No. 2 motor is in connection with that of No. 1 motor's main circuit wire marked No. 19, that connecting with wire marked No. 15, which is No. 2 motor's main circuit wire; the ground end wire of No. 2 motor's circuit, which is wire marked E–2, is still held in connection with main ground wire at motor.

Sixth Position

When using the sixth position the two motors are still held in parallel or multiple as on the fifth position, but with this exception, there being no exterior resistance, the current being direct to motor terminals, the current passing to No. 1 motor's circuit through wire marked No. 19 in controller, the current passing to No. 2 motor's circuit through wire marked No. 15 simultaneously. Wires marked No. 15 and No. 19 are held in circuit by the connection of the contact wiper marked R–3.

Seventh Position

When using the seventh position the two motors are still held in parallel or multiple as on the sixth position, but with this exception, the field circuit being shunted, the current shunted from No. 1 motor's field circuit is carried to the ground

through the main ground wire terminal in controller, the current shunted from No. 2 motor's field circuit is carried to the ground through the main ground wire terminal in the controller.

Explanatory Note

When moving the controlling cylinder from a series to a parallel connection, the No. 2 motor's circuit is entirely cut out when midway between the fourth and fifth positions, but when the two motors are placed in multiple the connection is not made in full until on the fifth position. The shunt resistance used in connection with motors is tapped from the field leads on the positive side of the field circuit. The ground ends of shunt resistance are placed in connection with controllers by wire marked L–1 and L–2. The safe running positions or continuous points on a type K or K–1 controller are 3, 4, 6, and 7, and the unsafe positions are 1, 2, and 5, which are rheostatic or resistance points. The safe running positions are indicated by the long raised bars on dial plate on cap of controller, and the rheostatic or resistance points are indicated by the short, raised bars on the dial plate.

CIRCUITS OF G. E. CONTROLLER, TYPE K-2

The following is the direction of the current in connection with a G. E. controller, type K–2.

With two motors in a series parallel connection with shunt method of operation.

First Position

The current passes from the trolley wire to the trolley wheel, through trolley pole to the trolley stand, then through

wire leading to No. 1 overhead switch (M. M. switch). When switch is closed the current passes through the wire leading to

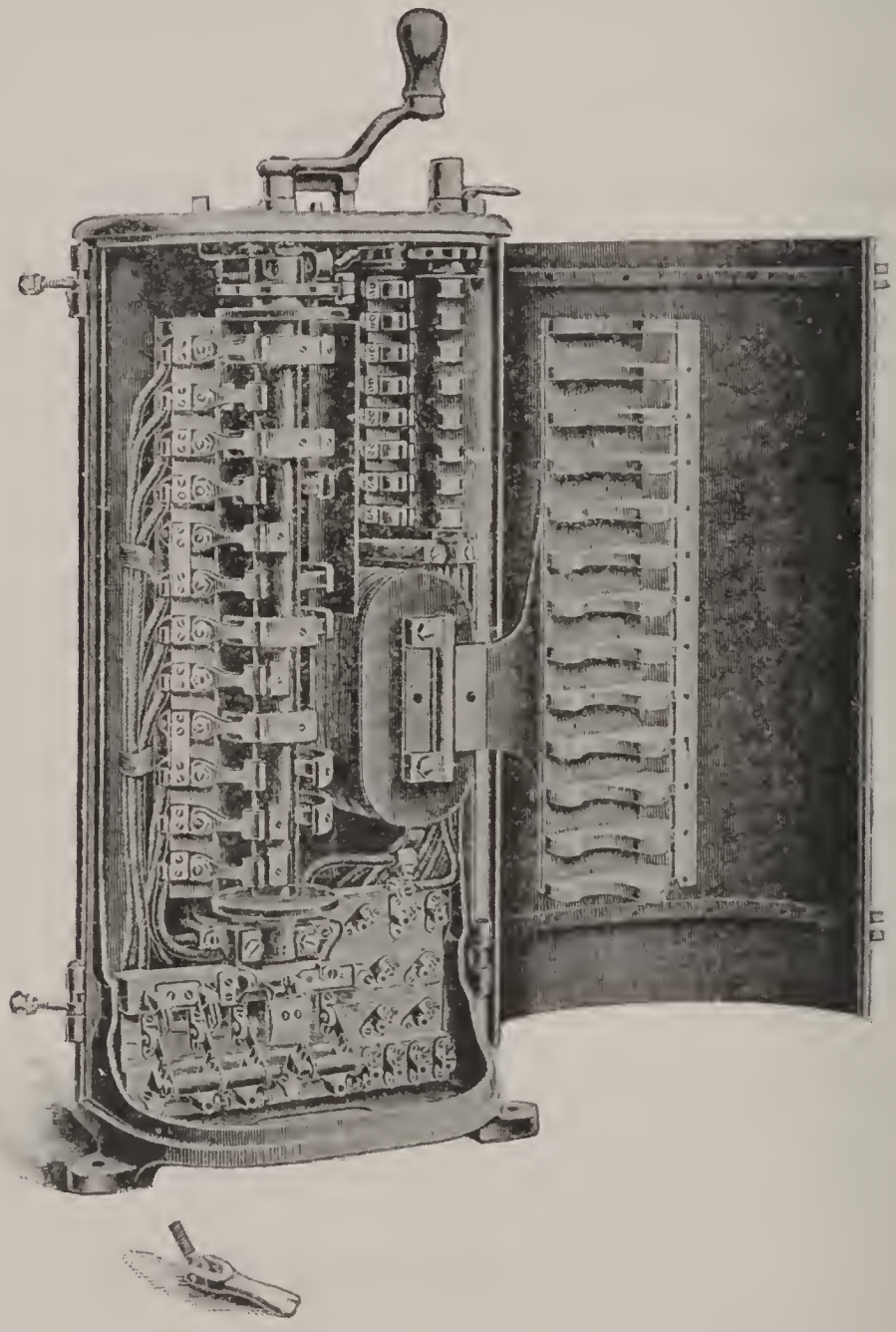


FIG. 8. — General Electrical Series — Parallel Controller, Form K–2, Fourth Position.

No. 2 overhead switch (M. M. switch); and when switch is closed the current passes through wire connecting with the fuse

box (cut-out box), leaving same and passing through wire connecting with lightning arrester.

When a T. H. lightning arrester is in circuit the current passes in at a point marked A, passing through blow-out magnet coil, leaving at a point marked B, then passing through a wire which connects with wire in cable marked T (meaning trolley). The current passes through this wire, which connects with terminals marked T on connection board of each controller, and also in connection with each blow-out magnet coil of controller. The current passes through blow-out magnet coil when in operation and then passes through wire connecting wtih the top contact wiper or finger of each controller. When controller cylinder is thrown to the first position the current passes through a wire marked R–1, which is the first wire connecting with the rheostat or resistance, leaving the rheostatic circuit through wire marked R–4, which connects with terminal marked R–4, on connection board of each controller, that connecting with wire marked No. 19 which is the main circuit wire of No. 1 motor's entire circuit, that connecting with the bottom contact wiper or finger of reverse switch or reverse cylinder. When reversing switch or cylinder is thrown ahead, for the forward motion, the current passes to and leaves at the second contact wiper upon reverse switch, passing through wire marked A–1, which is the wire connecting with the brush-holder of No. 1 motor's armature circuit. The current then passes through armature circuit, leaving at opposite brush-holder, passing through wire marked AA–1, which connects with the third contact wiper upon reverse switch. The current leaving at the fourth contact wiper upon reverse switch, then passing through wire marked F–1, which is wire connecting with the

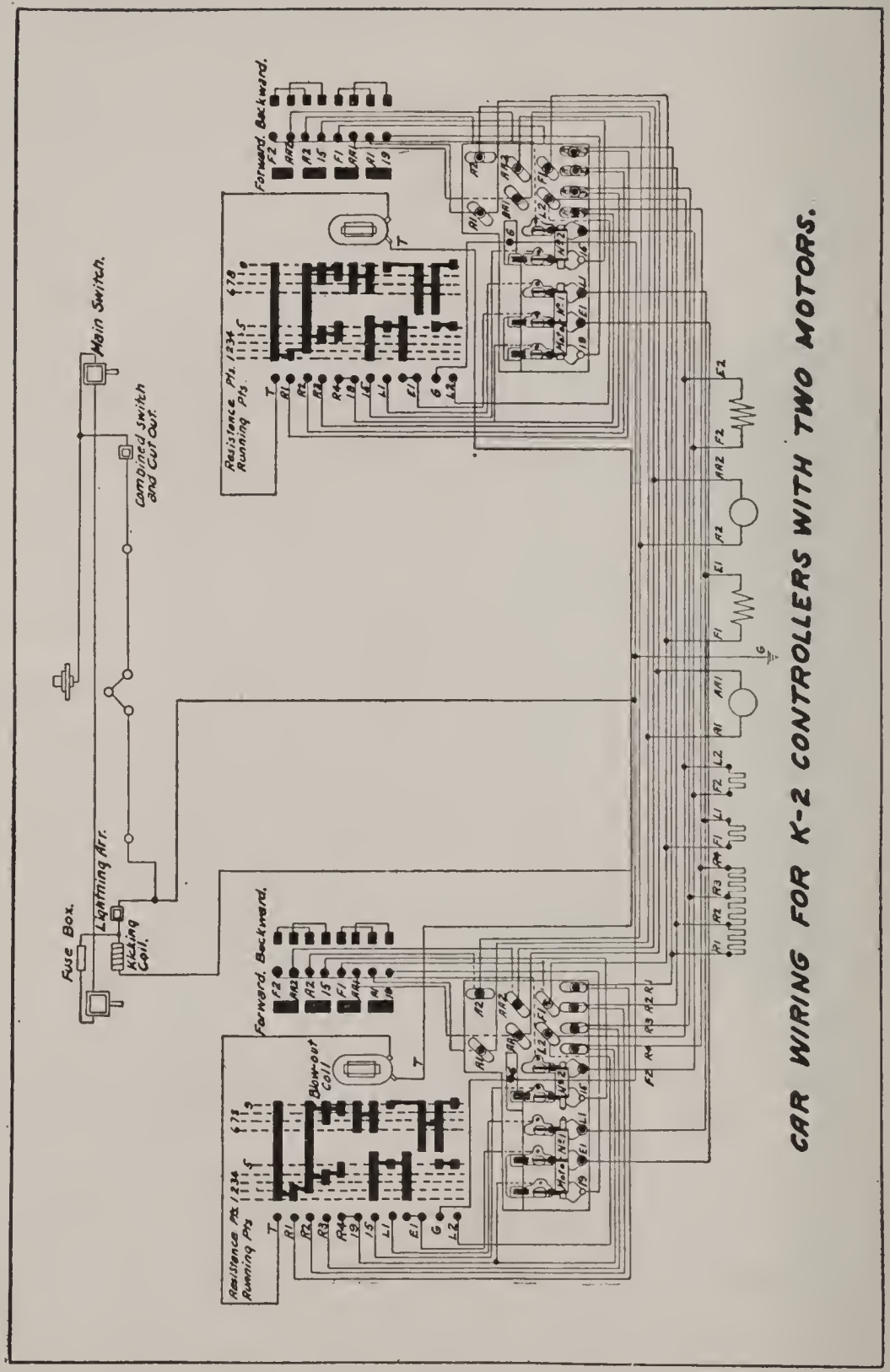

CAR WIRING FOR K-2 CONTROLLERS WITH TWO MOTORS.
Main Switch.
Combined Switch and Cut Out.
Lightning Arr.
Fuse Box.
Kicking Coil.
Forward. Backward.
Blow-out Coil
Resistance Pts. 1234 Running Pts.
Resistance Pts. 1234 Running Pts.
Forward. Backward.

FIG. 9.

field circuit of No. 1 motor, which is composed of either one, two, or four field coils, leaving same and passing through wire marked E–1, which is the ground end wire of No. 1 motor's entire circuit, that leading to and connecting with the center bar of No. 1 motor's cut-out switch. The current then passes through a wire and connects with the contact wipers marked E–1, and that in connection with (through cylinder) to wire marked No. 15, which is the main circuit wire of No. 2 motor's entire circuit, that connecting with the fifth contact wiper upon reverse switch; the current leaving at the sixth contact wiper upon the reverse switch, passing through a wire marked A–2, which is the wire connecting with the brush-holder of No. 2 motor's armature circuit; the current then passes through armature circuit, leaving at opposite brush-holder, then passing through wire marked AA–2, which connects with the seventh contact wiper upon reverse switch, the current leaving at the eighth contact wiper upon the reverse switch, then passing through wire marked F–2, which is wire connecting with the field circuit of No. 2 motor which is composed of either one, two, or four field coils, leaving same and passing through wire at E 2, which is the ground-end wire of No. 2 motor's entire circuit, that leading to and connecting with the main gound wire marked G at motor.

The above is the complete circuit of two motors in series, in connection with a G. E. controller, type K–2, on the first position.

Second Position

When using the second position the two motors are still held in series, the circuit being the same as on the first position, but with this exception, that instead of current passing through

wire marked R–1 it passes through wire marked R–2, which leads to and connects with the rheostatic circuit. On this position a portion of the resistance is cut out, leaving about one-third of the resistance in connection with motor circuits, which allows an increased speed of motors, by an increase of current to motor terminals.

Third Position

When using the third position, the two motors are still held in series, the circuit being the same as on the first and second positions, but with this exception, that instead of the current passing through the wire marked R–1 and R–2 it passes through wire marked R–3, which leads to and connects with the rheostatic circuit. On this position a still larger portion of the resistance is cut out leaving about one-twelfth of resistance in connection with motor circuits, which also allows an increased speed of motors over that of the second position by an increase of current to motor terminals.

Fourth Position

When using the fourth position the two motors are still held in series, the circuit being the same as on the first, second, and third positions, but with this exception, that there is no rheostatic connection whatever with motor connection, the current going direct to the motor terminals, which allows a still greater increase of speed of motors over that of the third position, by an increase of current to motor terminals.

Fifth Position

When using the fifth position the two motors are still held in series, as on the preceding positions and without exterior

resistance, but with this exception: the field circuits are shunted. The current shunted from No. 1 motor's field circuit is carried to the ground through No. 2 motor's armature circuit. The current shunted from No. 2 motor's field circuit is carried to the ground through the main ground wire terminal in the controller. The shunting of field circuits of motors Nos. 1 and 2 decreases the field strength which allows an increase of current at armature terminals which gives an added increase of speed to armatures.

Sixth Position

When using the sixth position the two motors are placed in parallel or multiple with one-third of resistance in connection with same, the current passing to rheostat or resistance through wire marked R–2. On this position the wire marked E–1, which is the ground-end wire of No. 1 motor's entire circuit, is placed in connection by the controlling cylinder to main ground wire in controller. The circuit of No. 2 motor is in connection with that of No. 1 motor's main circuit wire marked No. 19, that connecting with wire marked No. 15, which is No. 2 motor's main circuit wire. The ground-end wire of No. 2 motor circuit, which is marked E–2, is still held in connection with main ground wire at motor.

Seventh Position

When using the seventh position, the two motors are still held in parallel or multiple, as on the sixth position, but with this exception: only one-twelfth of resistance is placed in circuit with the same, the current passing to rheostat or resistance through wire marked R–3, which allows an increase of

current at motor terminals, and gives an added increase of speed to armature.

Eighth Position

When using the eighth position, the two motors are held in parallel or multiple, as on the seventh position, except without exterior resistance, the current being direct to motor terminals, passing to No. 1 motor's circuit through wire marked No. 19 in controller, the current passing to No. 2 motor's circuit through wire marked No. 15 simultaneously. Wires marked No. 19 and 15 are held in circuit by the connection of the contact wiper marked R-4.

Ninth Position

When using the ninth position, the two motors are still held in parallel or multiple as on the eighth position, but with this exception; the field circuits being shunted the current shunted from No. 1 motor's field circuit is carried to the ground through the main ground wire terminal in controller. The current shunted from No. 2 motor's field circuit is carried to the ground through the main ground wire in controller.

Explanatory Note

When changing the controller cylinder from a series to a parallel connection with a G. E. type K–2 controller, the No. 2 motor's circuit is entirely cut out when midway between the fifth and sixth positions, but when the two motors are placed in parallel the connection is not made in full until on the sixth position. The shunt resistances used in connection with motors are tapped from the field leads on the positive side of

the field circuit, the same as with a type K or K–1 controller. The ground ends of shunt resistance are placed in connection with controller by wires marked L–1 and L–2, the same as on a type K or K–1 controller. The safe running positions on a type K–2 controller are 4, 5, 8, and 9; the unsafe running positions are 1, 2, 3, 6, and 7, which are rheostatic or resistance points. The safe running positions are designated by the long raised bars on dial plate on cap of controller, and the rheostatic or resistance points are designated by the short raised bars on the dial plate.

DIRECTION OF CURRENT WITH G. E. TYPE K-10 OR 11 CONTROLLER

The course of the current from the trolley wire to the trolley contact wiper in controller is the same as that of the types K, K–1, or K–2.

First Position

When controlling cylinder is thrown to the first position the current passes through a wire marked R–1, which is the first wire connecting with the rheostat or resistance, leaving the rheostatic circuit through a wire marked R–5, which connects with the terminal marked R–5 on connection board of each controller, that connecting with the wire marked No. 19, which is the main circuit wire of No. 1 motor's entire circuit; that connecting with the bottom contact wiper or finger of reverse switch or reverse cylinder. When reversing switch or cylinder is thrown ahead for the forward motion the current passes to and leaves at the second contact wiper upon reverse switch passing through wire marked A–1, which is the wire

connecting with the brush-holder of No. 1 motor's armature circuit; the current then passes through armature circuit, leaving at opposite brush-holder, passing through wire marked

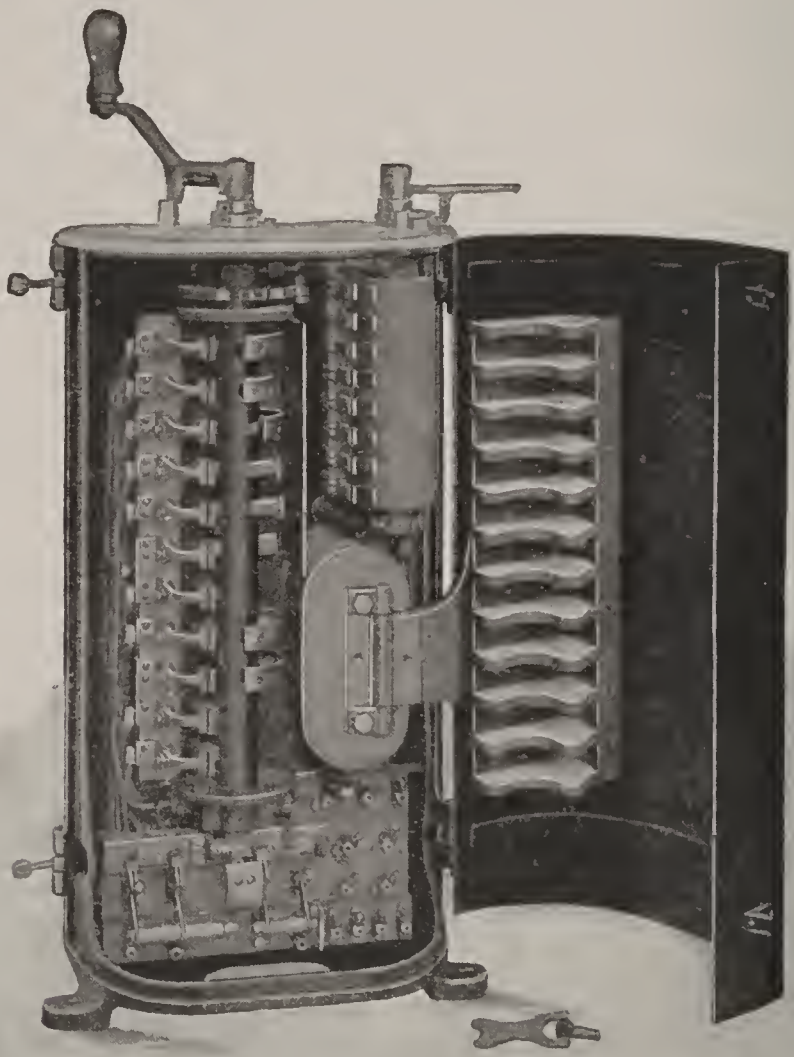


Fig. 10. — The K–11 Series Parallel Controller.

AA–1, which connects with the third contact wiper upon reverse switch; the current leaving at the fourth contact wiper upon reverse switch then passes through wire marked F–1, which is the wire connecting with the field circuit of No. 1

motor, which is composed of 1, 2, or 4 field coils, leaving same and passing through wire marked E–1, which is the ground-end wire of No. 1 motor's entire circuit, that leading to and connecting with the right-hand bar of No. 1 motor's cut-out switch; the current then passes through a wire and connects with the contact wipers marked E–1, and those in connection with (through cylinder) wire marked No. 15, which is the main circuit wire of No. 2 motor's entire circuit, that connecting with the fifth contact wiper upon reverse switch, the current leaving at the sixth contact wiper upon the reverse switch passing through a wire marked A–2, which is the wire connecting with the brush-holder of No. 2 motor's armature circuit. The current then passes through motor No. 2 armature circuit, leaving at opposite brush-holder, passing through wire marked AA–2, which connects with the seventh contact wiper upon reverse switch, the current leaving at the eighth contact wiper upon reverse switch, then passing through wire marked F–2, which is wire connecting with the field circuit of No. 2 motor, which is composed of 1, 2, or 4 field coils, leaving same and passing through a wire marked E–2, which is the ground-end wire of No. 2 motor's entire circuit, that leading to and connecting with the main ground wire marked G at motors.

The above is the complete circuit of two motors in series in connection with a G. E. controller, types K–10 or K–11, on the first position.

Second Position

When using the second position the two motors are still held in series, the circuit being the same as on the first position, but with this exception: instead of the current passing through

Car Wiring For K-11 Controllers With 2 Motors

Also Correct for 2 K-10 Controllers with 2 Motors when 2 Circuit Breakers are used.

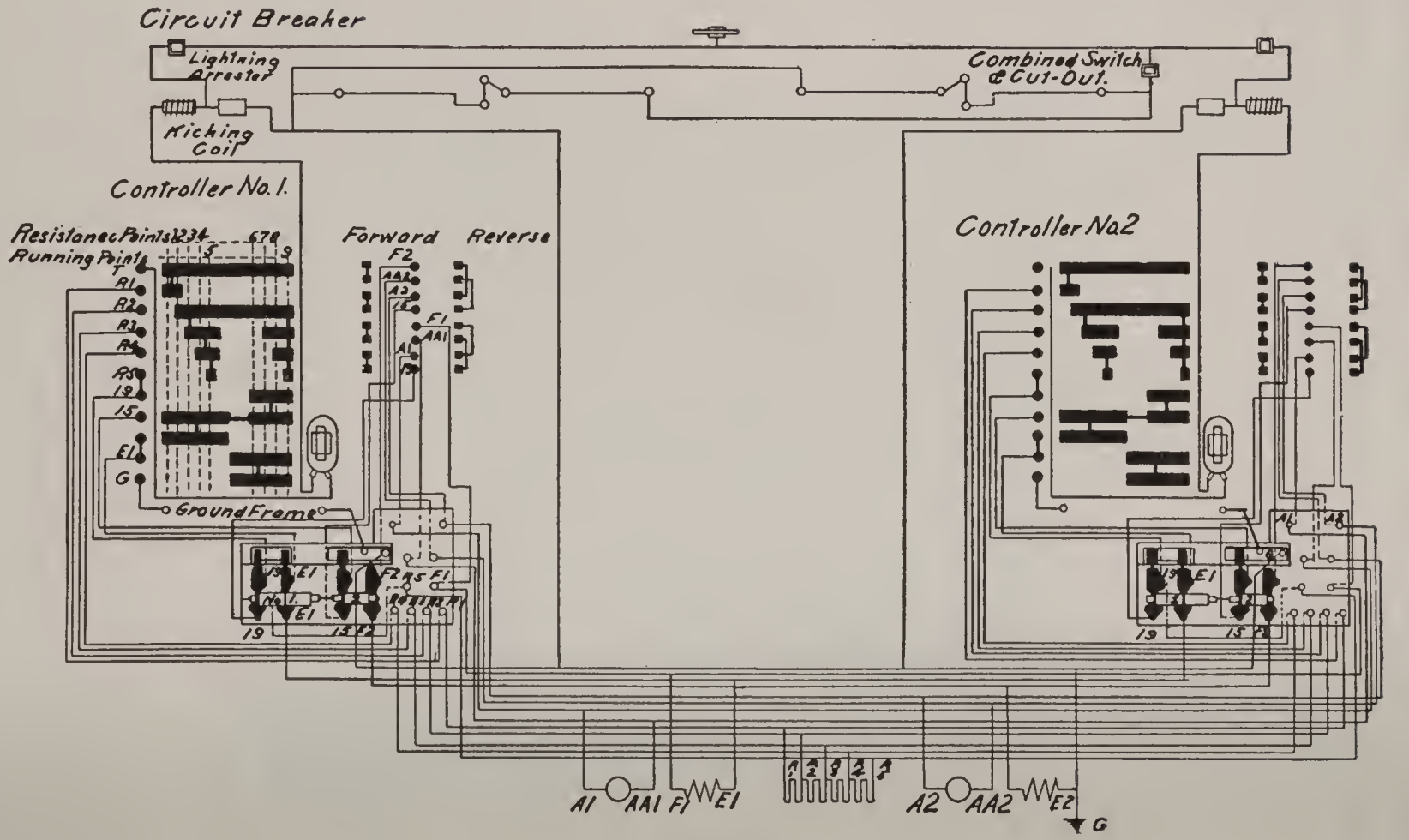


FIG. 11.

the wire marked R–1 it passes through the wire marked R–2, which leads to and connects with the rheostatic circuit.

On this position a portion of the resistance is cut out, leaving about three-fourths in connection with motor circuits, which allows an increase of speed of motors by an increase of current to the motor terminals.

Third Position

When using the third position the two motors are still held in series, the circuit being the same as on the first and second positions, but with this exception: instead of the current passing through the wires marked R–1 and R–2 it passes through a wire marked R–3, which leads to and connects with the rheostatic circuit. On this position a still larger portion of the resistance is cut out, leaving about one-half of the resistance in connection with motor circuits, which also allows an increase of speed of motors over that of the second position, by an increase of current to the motor terminals.

Fourth Position

When using the fourth position the two motors are still held in series, the circuit being the same as on the first, second, and third positions, but with this exception: instead of the current passing through wires marked R–1, R–2, or R–3, it passes through a wire marked R–4, which leads to and connects with the rheostatic circuit. On this position a still larger portion of the resistance is cut out, leaving about one-fourth in connection with the motor circuits, which also allows an increase of speed of motors over that of the third position, by an increase of current at the motor terminals.

Fifth Position

When using the fifth position the two motors are still held in series, the circuit being the same as on the first, second, third and fourth positions, but with this exception: there is no rheostatic connection whatever with the motor circuit; the current flowing direct to motor terminals, which allows a still greater increase of speed of motors over that of the fourth position, by an increase of current to motor terminals.

Sixth Position

When using the sixth position the two motors are placed in parallel or multiple with about three-fourths of the resistance in connection with the same, the current passing to rheostat or resistance through the wire marked R–2. On this position the wire marked E–1, which is the ground-end wire of No. 1 motor's entire connections, is placed in connection by the controlling cylinder to main ground wire in controller. The circuit of No. 2 motor is in connection with that of No. 1 motor's main circuit wire marked No. 19, that connecting with the wire marked No. 15, which is No. 2 motor's main circuit wire. The ground-end wire of No. 2 motor's circuit is always in connection with the main ground wire at the motor.

Seventh Position

When using the seventh position the two motors are still held in parallel or multiple, as on the sixth position, but with this exception: about one-half of the resistance is placed in circuit, the current passing through rheostat, or resistance, through a wire marked R–3, which allows an increase of

current at motor terminals and gives an increased speed to armatures.

Eighth Position

When using the eighth position the two motors are still held in parallel or multiple, as on the sixth and seventh positions, but with this exception: about one-fourth of the resistance is placed in circuit, the current passing to rheostat or resistance through a wire marked R–4, which allows an increase of current at the motor terminals and gives an added increase of speed to armatures.

Ninth Position

When using the ninth position the two motors are still held in parallel or multiple, as on the sixth, seventh, and eighth positions, but with this exception: all the exterior resistance being cut out, the current being direct to motor terminals, passing to No. 1 motor circuit through wire marked No. 19 and to No. 2 motor's circuit through wire marked No. 15 simultaneously.

Wires marked No. 19 and No. 15 are held in circuit by the connection of the contact wiper marked R–5.

When changing controller cylinder from a series to a parallel connection, the No. 2 motor's circuit is entirely cut out when midway between the fifth and sixth positions, the same as that of a circuit with a G. E. type K–2 controller. The two motors are placed in multiple when the controller is thrown to the sixth position, as on the type K–2 controller.

The safe running positions of a G. E. type K–10 or K–11 controller are the fifth and ninth positions. The unsafe running positions are one, two, three, four, six, seven, and eight,

which are rheostatic, or resistance points or positions. The safe running positions are designated by the long raised bars on the dial plate on cap of controller, and the rheostatic or resistance points are designated by the short raised bars on the dial plate.

REVERSING SWITCH

The reversing switch or cylinder of a G. E. controller is constructed of wood or some other insulating material and is cylindrical in shape. The contact plates, of which they are sixteen in number, are mounted upon this cylinder. They are for the purpose of causing a change in the direction of the armature or armatures. Eight of them are for the forward motion, and eight for the backward motion. When using the forward motion, eight of the contact plates of the reverse switch are connected in pairs, beginning at the bottom of the reverse switch. The connections are made usually through a heavy wire, about No. 4 size, embedded in the wood or insulating material of the switch. In this connection of both motors there are four pairs of contact plates required, the first two of which from bottom of switch upward represent No. 1 motor's connections, while the third and fourth pair, counting from the bottom, represent No. 2 motor's connection.

The bottom contact wiper of the first pair is the No. 19 wire connection, and the second contact wiper of this pair is the A–1 lead connection. The third contact wiper upon the reverse switch, which is the first contact wiper of the second pair, is the AA–1 lead connection. The fourth contact wiper up, which is the second contact wiper of the second pair, is the F–1 lead connection. The fifth contact wiper upon reverse switch,

which is the first wiper of the third pair, is the No. 15 wire connection. The sixth contact wiper upon the reverse switch, which is the second contact wiper of the third pair, is the A–2 lead connection.

The seventh contact wiper upon the reverse switch, which is the first contact wiper of the fourth pair, is the AA–2 lead connection.

The eighth contact wiper upon the reverse switch, which is the second contact wiper of the fourth pair, is the F–2 lead connection.

When reversing for a backward motion, the other eight contact plates are placed in connection with contact wipers and are connected in pairs the same as for the forward motion, but with this exception: they are in alternate connection, that is, the first and third are in connection with each other, and also the second and fourth, which comprises No. 1 motor's connection, also the fifth and seventh, are in connection with each other, and the sixth and eighth contact plates are in connection, which comprises No. 2 motor's connection.

The first and third contact plates represent, respectively, the connection of No. 19 wire and the AA–1 armature lead, and the second and fourth contact plates represent the connection of the A–1 armature lead and the F–1 field lead.

The fifth and seventh contact plates represent, respectively, the connection of No. 15 wire and AA–2 armature lead, and the sixth and eighth contact plates represent the connection of the A–2 armature lead and F–2 field lead.

G. E. K-6 CONTROLLER

The G. E. K–6 controller is adapted for a four-motor equipment. The controller has eleven positions, of which six are in series and five in parallel.

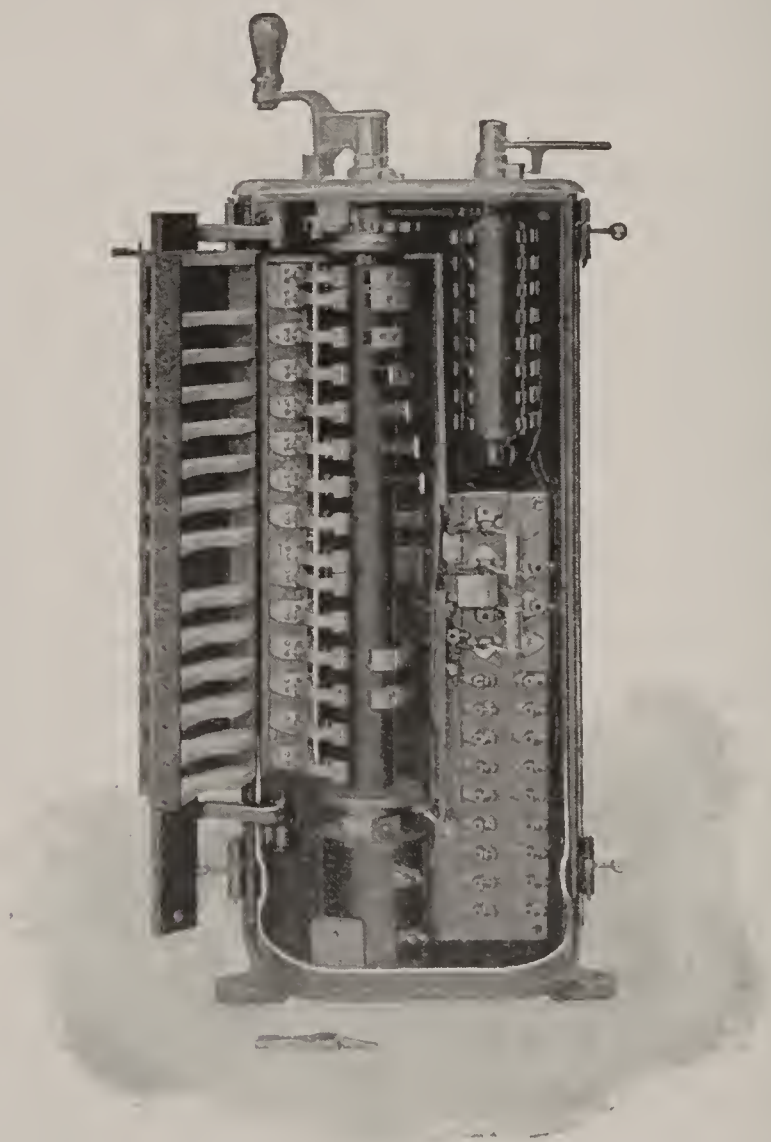


FIG. 12. — The K–6 Series Parallel Controller.

First Position

When on the first position of controller, the four motors are in a series multiple motor connection with exterior resistance; the current entering the rheostat, through wire R–1,

leaving rheostatic field at wire R–6, which connects with wire No. 19 of each controller which is in connection with reverse switch at terminals of motors 1 and 3. The circuit from this point for motors is the same as that of the type K–10 or 11 controller.

Second Position

When on the second position of controller, the circuit is the same as that of the first position; the current entering the rheostatic field through wire R–2 and leaving at wire R–6, which connects wire with No. 19.

Third Position

When on the third position of controller, the circuit is the same as that of the second position, with this exception: the current entering the rheostatic field through wire R–3, leaving at wire R–6, which connects with wire No. 19.

Fourth Position

When on the fourth position the circuit is the same as that of the third position, with this exception: the current entering rheostatic field, through wire marked R–4, leaving at wire marked R–6 which connects with wire No. 19.

Fifth Position

When on the fifth position of controller, the circuit is the same as that of the fourth position, with this exception: the current entering the rheostatic field through wire R–5, leaving at wire R–6, which connects with wire No. 19.

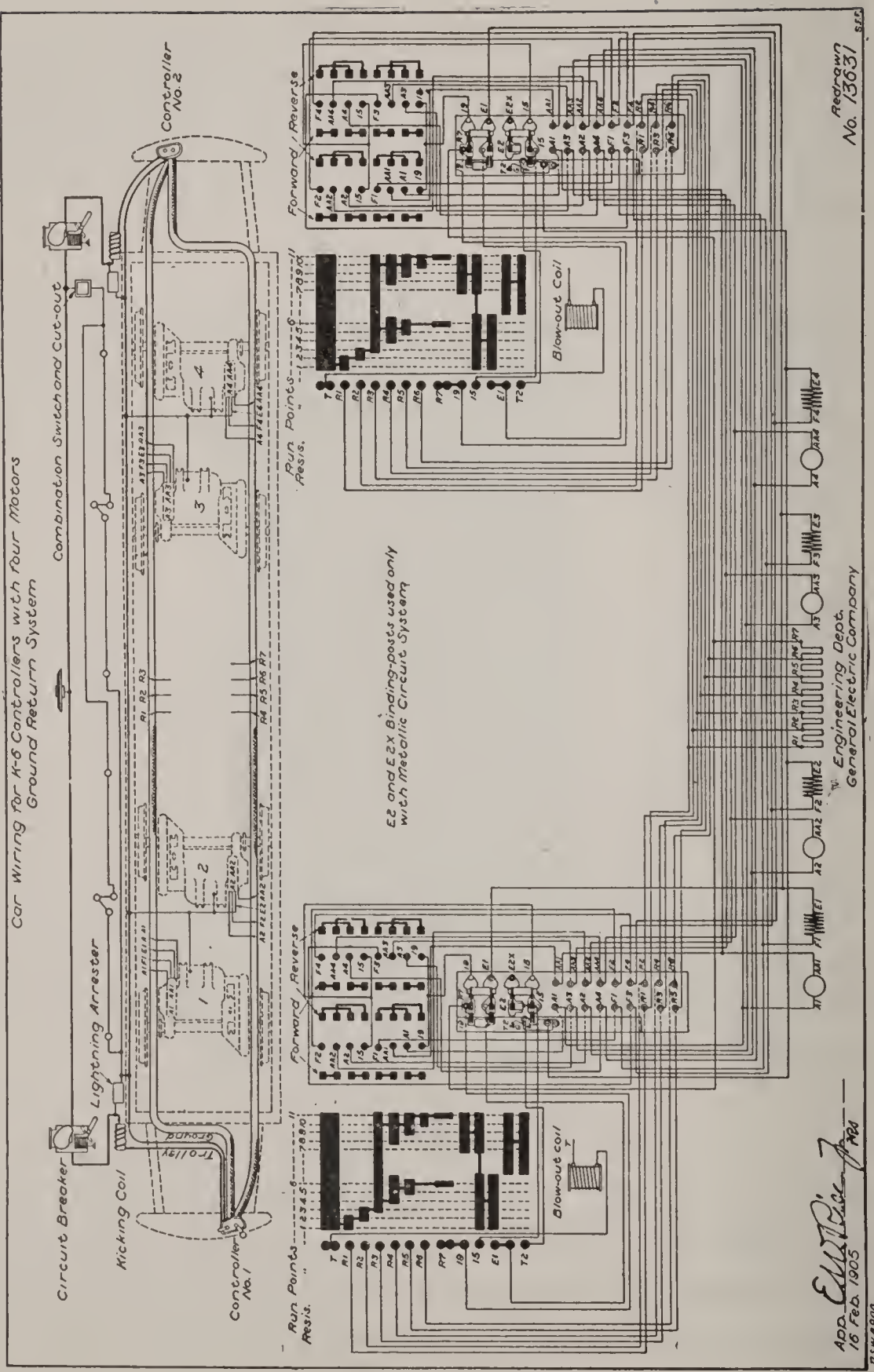

Car Wiring for K-6 Controllers with four Motors
Ground Return System
Combination Switch and Cut-out
Controller No. 2
Controller No. 1
Circuit Breaker
Lightning Arrester
Kicking Coil
Trolley
Ground
Forward / Reverse
Run Points
Resis.
Blow-out Coil
E2 and E2x Binding-posts used only with Metallic Circuit System
Engineering Dept. General Electric Company
Redrawn No. 13631
ADD. 16 Feb. 1905

FIG. 13.

Sixth Position

When on the sixth position of controller, the circuit is the same as that of the fifth position, with this exception: the four motors are in a series multiple connection, without exterior resistance, the current being direct to motor terminals. This is called the *series safe running position.*

Seventh Position

When on the seventh position of controller, the motors are in a multiple connection with exterior resistance, the current entering the rheostatic field through wire R–2 and leaving at wire R–6, which connects with wires Nos. 19 and 15.

Eighth Position

When on the eighth position of controller, the circuit is the same as that of the seventh position, with this exception: the current enters the rheostatic field through wire R–3, leaving at wire R–6, which connects with wires Nos. 19 and 15.

Ninth Position

When on the ninth position of controller, the circuit is the same as that of the eighth position, with this exception: the current enters the rheostatic field through wire R–4, leaving at wire R–6, which connects with wires Nos. 19 and 15.

Tenth Position

When on the tenth position of controller, the circuit is the same as that of the ninth position, with this exception: the cur-

rent enters the rheostatic field through wire R–5, leaving at wire R–6, which connects with wires Nos. 19 and 15.

Eleventh Position

When on the eleventh position of controller, the circuit is the same as that of the tenth position, with this exception: the motors are in a multiple connection without exterior resistance; the current being direct to motor terminals. This is called the *multiple or parallel safe running position.*

Explanatory Note. Reverse Switch Connections

The connection of motors Nos. 1 and 2 are at left-hand side of reverse cylinder. The connections of motors Nos. 3 and 4 are at right-hand of reverse cylinder.

Wire No. 19 is in connection with motors Nos. 1 and 3; wire No. 15 is in connection with motors 2 and 4.

The four lower contact wipers of reverse cylinder, located on the left-hand side, are for No. 1 motor connection. The four top contact wipers on the left-hand side of reverse cylinder are for No. 2 motor's connection. The four lower contact wipers on the right-hand side of reverse cylinder are for No. 3 motor's connection. The four top contact wipers on the right-hand side of reverse cylinder are for No. 4 motor's connection.

G. E. K-14 CONTROLLER

The G. E. K–14 controller is adapted for a four-motor equipment used on heavy types of cars. The motors used in connection with this controller are usually 60 horse-power. The G. E. K–14 controller has thirteen positions, of which seven are in series and six in multiple.

First Position

When on the first position of controller, the motors are in a series multiple connection with exterior resistance; the current entering rheostatic field through wire marked R–1, leaving at wire marked R–7, which is in connection with wire No. 19 of each controller, which is in connection with reverse switch at terminals of motors 1 and 3. The circuit from this point for motors are the same as that of a type K–6 controller.

Second Position

When on the second position of controller, the circuit is the same as that of the first position, with this exception: the current entering the rheostatic field through wire marked R–2, leaving at wire marked R–7, which is in connection with wire No. 19.

Third Position

When on the third position of controller, the circuit is the same as that of the second position, with this exception: the current enters the rheostatic field through wire marked R–3, leaving at wire marked R–7, which is in connection with wire No. 19.

Fourth Position

When on the fourth position of controller, the circuit is the same as that of the third position, with this exception: the current enters the rheostatic field through wire marked R–4, leaving at wire marked R–7, which connects with wire No. 19.

Fifth Position

When on the fifth position of controller, the circuit is the same as that of the fourth position, with this exception: the current enters the rheostatic field through wire marked R–5, leaving at wire marked R–7, which is in connection with wire No. 19.

Sixth Position

When on the sixth position of controller, the circuit is the same as that of the fifth position, with this exception: the current enters the rheostatic field through wire marked R–6, leaving at wire marked R–7, which connects with wire No. 19.

Seventh Position

When on the seventh position of controller, the circuit is the same as that of the fourth position, with this exception: the four motors are in a series multiple connection without exterior resistance; the current being direct to motor terminals. This is called the series safe running position.

Eighth Position

When on the eighth position of controller, the four motors are in a multiple connection with exterior resistance; the current entering the rheostatic field through wires marked R–2, leaving at wire marked R–7, which connects with wires Nos. 19 and 15.

Ninth Position

When on the ninth position of controller, the circuit is the same as that on the eighth position, with this exception: the

current enters the rheostatic field through wire marked R–3, leaving at wire marked R–7, which connects with wires Nos. 19 and 15.

Tenth Position

When on the tenth position of controller, the circuit is the same as that of the ninth position, with this exception: the current enters the rheostatic field through wire marked R–4, leaving at wire marked R–7, which connects with wires Nos. 19 and 15.

Eleventh Position

When on the eleventh position of controller, the circuit is the same as that of the tenth position, with this exception; the current enters the rheostatic field through wire marked R–5, leaving at wire marked R–7, which connects with wires Nos. 19 and 15.

Twelfth Position

When on the twelfth position of controller, the circuit is the same as that of the eleventh position, with this exception: the current enters the rheostatic field through wire marked R–6, leaving at wire marked R–7, which connects with wires Nos. 19 and 15.

Thirteenth Position

When on the thirteenth position of controller, the circuit is the same as that of the twelfth position, with this exception: the motors are in a multiple connection without exterior resistance, the current being direct to motor terminals. This is called the multiple or parallel safe running position.

Explanatory Note. Reverse Switch Connections

The connection of motors Nos. 1 and 2 are at left-hand side of reverse cylinder. The connection of motors Nos. 3 and 4 are at right-hand of reverse cylinder.

Wire No. 19 is in connection with motors Nos. 1 and 3; wire No. 15 is in connection with motors 2 and 4.

The four lower contact wipers of reverse cylinder, located on the left-hand side, are for No. 1 motor connection. The four top contact wipers on the left-hand side of reverse cylinder are for No. 2 motor's connection. The four lower contact wipers on the right-hand side of reverse cylinder are for No. 3 motor's connection. The four top contact wipers on the right-hand side of reverse cylinder are for No. 4 motor's connection.

G. E. TYPE K-8 OR 9 CONTROLLER

The G. E. K–8 or 9 controller are of a series parallel type, and adapted for a series multiple circuit, of which there are nine positions; five for series running positions, and four for parallel.

First Position

When on the first position of controller, the two motors are in a series connection, with exterior resistance, the current entering the rheostatic field through wire marked R–1, leaving at wire marked R–5, which connects with wire No. 19 of each controller, which is in connection with reverse switch at terminals of motor No. 1.

Second Position

When on the second position of controller, the circuit is the same as that of the first position, with this exception: the cur-

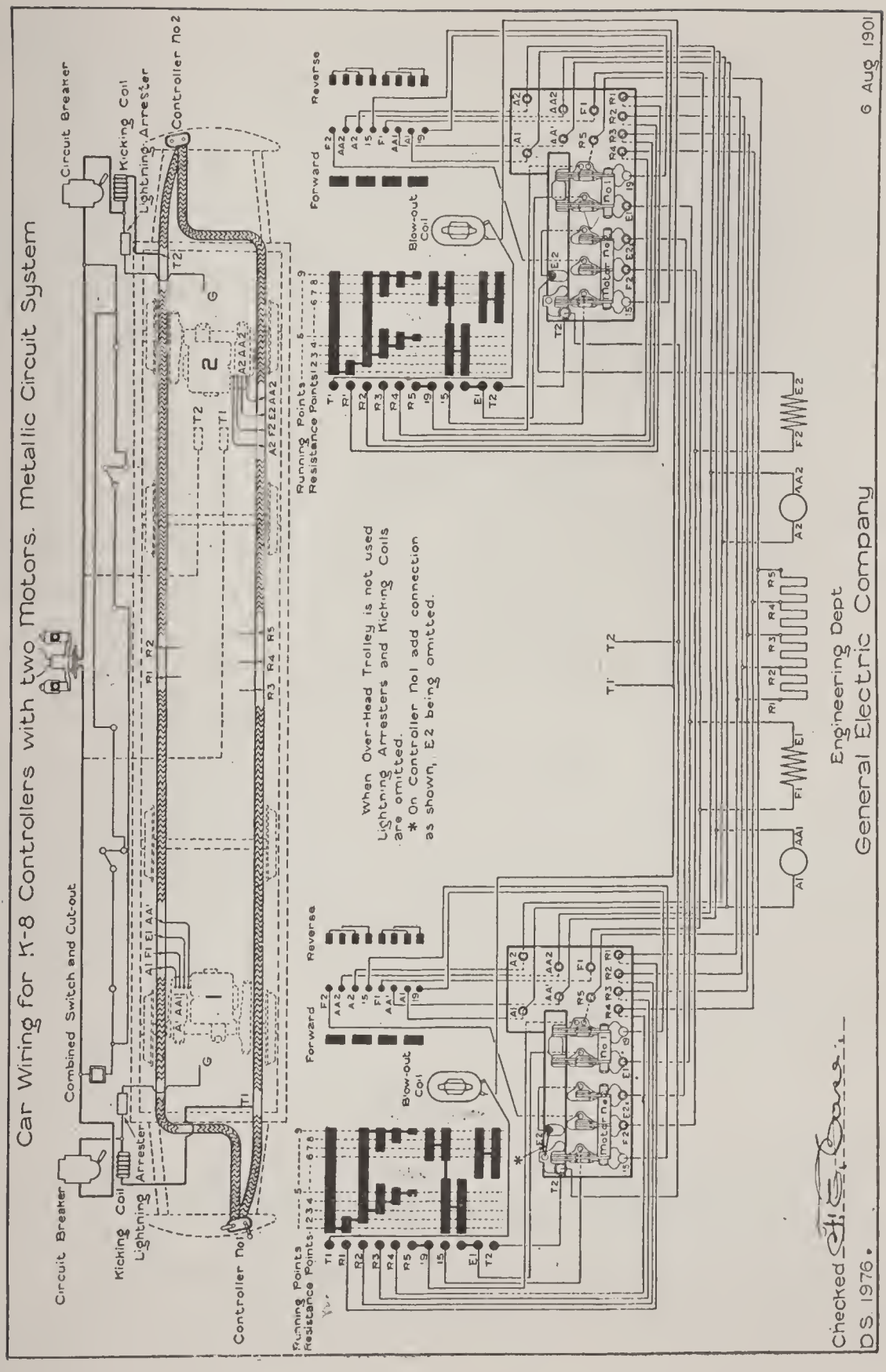

Car Wiring for K-8 Controllers with two Motors. Metallic Circuit System
Circuit Breaker
Combined Switch and Cut-out
Kicking Coil
Lightning Arrester
Controller No1
Controller No2
Running Points
Resistance Points
Forward
Reverse
Blow-out Coil
When Over-Head Trolley is not used Lightning Arresters and Kicking Coils are omitted.
* On Controller No1 add connection as shown, E2 being omitted.
Engineering Dept
General Electric Company
6 Aug 1901
Checked
DS 1976.

FIG. 14.

rent enters the rheostatic field through wire marked R–2, leaving at wire marked R–5, which connects with wire No. 19.

Third Position

When on the third position of controller, the circuit is the same as that of the second position, with this exception: the current enters the rheostatic field through wire marked R–3, leaving at wire marked R–5, which connects with wire No. 19.

Fourth Position

When on the fourth position of controller, the circuit is the same as that of the third position, with this exception: the current enters the rheostatic field through wire marked R–4, leaving at wire marked R–5, which connects with wire No. 19.

Fifth Position

When on the fifth position of controller, the circuit is the same as that of the fourth position, with this exception: the two motors are in a series connection without exterior resistance; the current being direct to motor terminals. This is called the *series safe running position.*

Sixth Position

When on the sixth position of controller, the two motors are in a multiple or parallel connection with exterior resistance; the current entering the rheostatic field through wire marked R–2, leaving at wire marked R–5, which connects with wires Nos. 19 and 15.

Seventh Position

When on the seventh position of controller, the circuit is the same as that of the sixth position, with this exception: the current enters the rheostatic field through wire marked R–3, leaving at wire marked R–5, which connects with wires Nos. 19 and 15.

Eighth Position

When on the eighth position of controller, the circuit is the same as that of the seventh position, with this exception: the current enters the rheostatic field through wire marked R–4, leaving at wire marked R–5, which connects with wires Nos. 19 and 15.

Ninth Position

When on the ninth position of controller, the circuit is the same as that of the eighth position, with this exception: the two motors are in a multiple or parallel connection without exterior resistance; the current being direct to motor terminals. This is called the *multiple or parallel safe running positions.*

Explanatory Note

The motor connection of reverse switch terminals are the same as those of a type K–10 controller.

WESTINGHOUSE 28-A CONTROLLER

The direction of the current in connection with a Westinghouse 28–A controller is identical to that of the General Electric up to and including the trolley contact wiper in controller.

When the controlling cylinder is on the first position, the current passes from the trolley contact wiper to the contact wiper marked R–1, that in connection by wire to diverter No. 2, leaving said diverter (rheostat, or resistance) circuit at terminal marked R–3, that in connection by wire to arc coil in controller. The negative lead of this coil being in connection with the lower right-hand corner binding-post of No. 1 motor's cut-out switch, that in connection with the top right-hand binding-post of No. 1 motor's cut-out switch, that being in connection with the left-hand binding-post of contact wiper of reverse switch (when speaking of the left-hand binding-post of the reversing switch); this is to be taken from the exact center of reversing switch disk; this in connection with the binding-post marked F–1 +; that in connection with the cable lead marked F–1 —, which is the wire connecting with No. 1 motor's field circuit, leaving same through wire marked F–1 +; that in connection with terminal in controller marked F–1 —; that in connection with binding-post of reverse switch marked F–1 —; that in connection with binding-post marked A–1 +; that in connection with wire in cable marked A–1 +; which is the wire connecting with the positive brush-holder of No. 1 motor's armature circuit, leaving the same at the opposite brush-holder, and then through wire marked A–1 —, which connects with terminal in controller marked A–1 —, and that in connection with the top left-hand binding-post of No. 1 motor's cut-out switch; that in connection with the bottom left-hand binding-post of No. 1 motor's cut-out switch; that in connection with the terminal and contact wiper marked R–4. The current at this point passes through a wire marked R–4, which is in connection with No. 1 diverter, leaving same at terminal marked R–5, which

is in connection with (through cylinder) the main circuit wire of No. 2 motor's entire connection; that in connection with the lower left-hand binding-post of No. 2 motor's cut-out switch; that in connection with the top left-hand binding-post of No. 2 motor's cut-out switch, that in connection with the right-hand binding-post of reverse switch. The current then passes to the binding-post marked F–2+; that in connection with wire in cable marked F–2–, which is the wire connecting with No. 2 motor's field circuit, leaving same at terminal and through wire marked F–2+, connecting with wire in controller marked F–2–; that in connection with through reverse switch to binding-post marked A–2+. The current then passes through wire marked A–2–, which connects with the positive brush-holder of No. 2 motor's armature circuit, leaving same at opposite brush-holder through wire marked A–2+, which leads to and connects with the main ground wire at motor.

The above is for two motors in series on first position, with Westinghouse 28–A controller in connection with No. 46 diverters. ("Diverter" in this system means the rheostat or resistance.)

Second Position

When using the second position the two motors are still in series, as on the first position, the course of the current being the same, but with this exception: that the No. 1 diverter is cut out of circuit, with current passing through No. 2 diverter, as on the first position, which allows an increase of current to motor terminals, giving an increased speed to armatures.

Third Position

When using the third position the two motors are still in series, as on the first and second positions, the course of the current being the same; but with this exception: that about one-half of panels of No. 2 diverter are cut out, the current passing to diverter through wire marked R–2, which allows an increase of current to motor terminals, giving an increase of speed to armature.

Fourth Position

When using the fourth position, the two motors are still in series as on the first, second, and third positions, the course of the current being the same, but with this exception: both of the diverters are cut out of the circuit, the current being direct to motor terminals, giving a still greater increase of speed to armature; this is the *first direct or safe running position on controller*, marked one-half speed on dial plate.

Fifth Position

When using the fifth position, the two motors are placed in a parallel or multiple connection, with the No. 2 diverter in connection with same. On this position the diverter wires, marked R–4 and R–5, act as a ground connection for No. 1 motor's circuit, they being in connection with the main ground wire in controller. The No. 2 motor's circuit is held in connection by the main circuit wire of No. 1 motor's connection.

Sixth Position

When using the sixth position, the two motors are still in multiple, the course of the current being the same as on the

fifth position, but with this exception: about one-half of the panels of No. 2 diverter are cut out of circuit, the current passing to diverter though wire marked R–2, which allows an increase of current to motor terminals, giving an increased speed to armatures.

Seventh Position

When using the seventh position, the two motors are still held in multiple, the course of the current being the same as on the fifth and sixth positions, but with this exception: the entire diverter circuit being cut out, the current being direct to motor terminals, which allows the maximum speed of armature. This is the *second direct or safe running position* on controller, marked full speed on dial plate.

WESTINGHOUSE 28 K. B. CONTROLLER

The Westinghouse 28 K. B. Controller is constructed for a four-motor equipment, and is of the series parallel type. There are five positions in series and five in parallel. The motors when using the series position are in a series multiple connection. Motors Nos. 1 and 3 and Nos. 2 and 4 are in multiple.

First Position

When on the first position with controller, the four motors are in a series multiple connection with full exterior resistance in circuit. The current entering the rheostat at wire R-1 and leaving at wire R–5.

Second Position

When on the second position of controller, the circuit is the same as that of the first position, with this exception: a part of the resistance is cut out by current entering rheostat through wire R–1 and leaving at wire R–4.

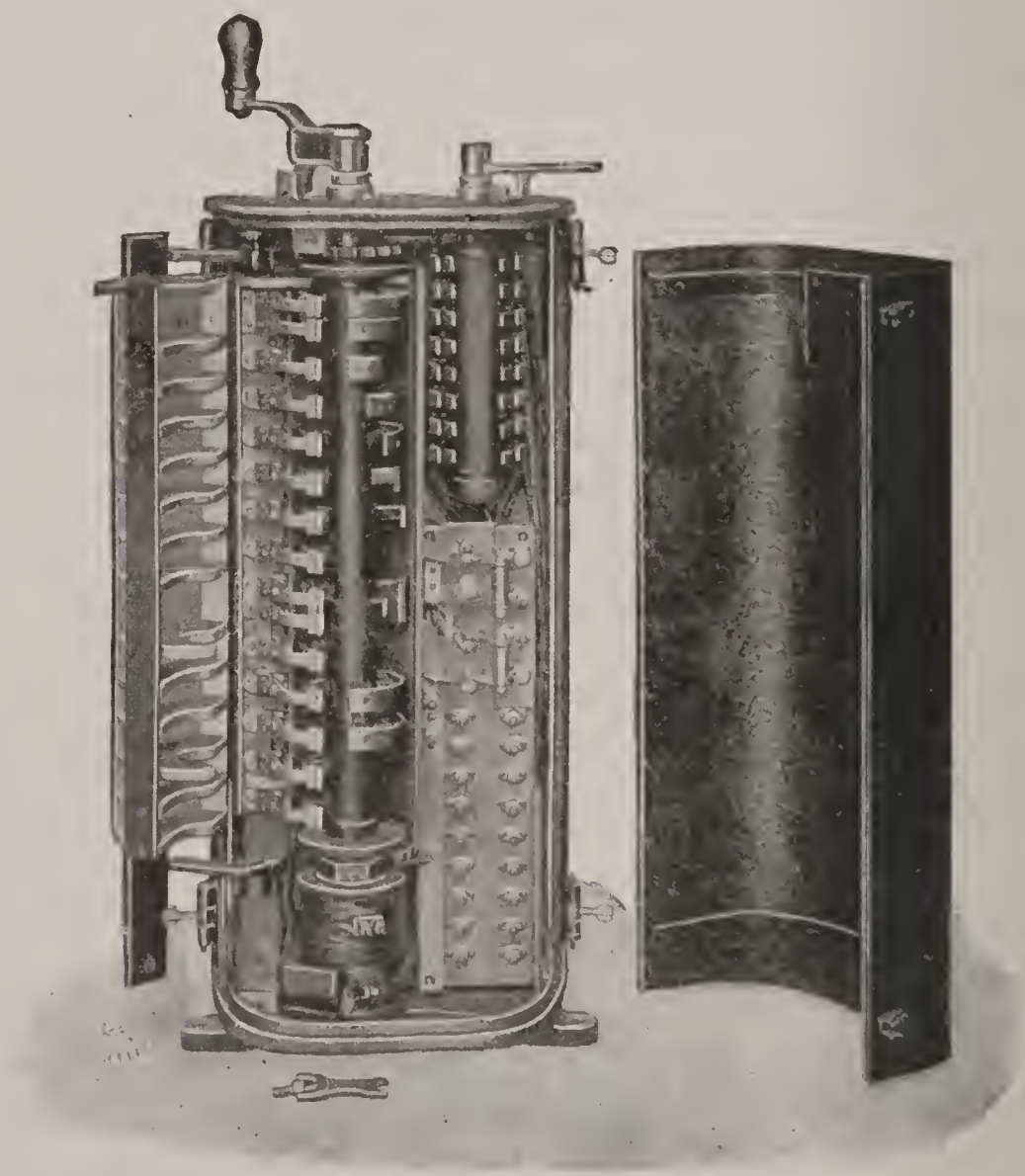


Fig. 15.

Third Position

When on the third positon of controller, the circuit is the same as that of the second position, with this exception: the current entering the rheostat at wire R–1 and leaving at wire R–3.

Fourth Position

When on the fourth position of controller, the circuit is the same as that of the third position, with this exception: the current entering the rheostat at wire R–2 and leaving at wire R–3.

Fifth Position

When on the fifth position of controller, the motors are in a series multiple connection without exterior resistance. This is known as the *series safe running position.*

Sixth Position

When on the sixth position of controller, the motors are in a multiple connection with exterior resistance. The current entering rheostat at wire R–4 and leaving at wire R–5.

Seventh Position

When on the seventh position of controller, the circuit is the same as that of the sixth position, with this exception: the current entering the rheostat at wire R–4 and leaving at wire R–5 and R–1.

Eighth Position

When on the eighth position of controller, the circuit is the same as that of the seventh position, with this exception: the

current entering the rheostat at wires R–2 and R–4 and leaving at wires R–1 and R–5.

Ninth Position

When on the ninth position of controller, the circuit is the same as that of the eighth position, with this exception: the current entering the rheostat at wires R–4 and R–2 and leaving at wires R–3 and R–5.

Tenth Position

When on the tenth position of controller, the circuit is the same as that of the ninth position, with this exception; the four motors are in a multiple connection, without exterior resistance. This is known as the *parallel safe running position.*

G. E. K-27 CONTROLLER

The G. E. type K–27 controller is designed for a two-motor equipment, and is of a series parallel type. There are eight positions on controller, four in series, and four in parallel.

First Position

When on the first position of controller, the two motors are in a series connection with exterior resistance. The current entering rheostat at wire R–1 and leaving at wire R–5.

Second Position

When on the second position of controller, the circuit is the same as that of the first position, with this exception: the current enters rheostat at wire R–2, leaving at wire R–5.

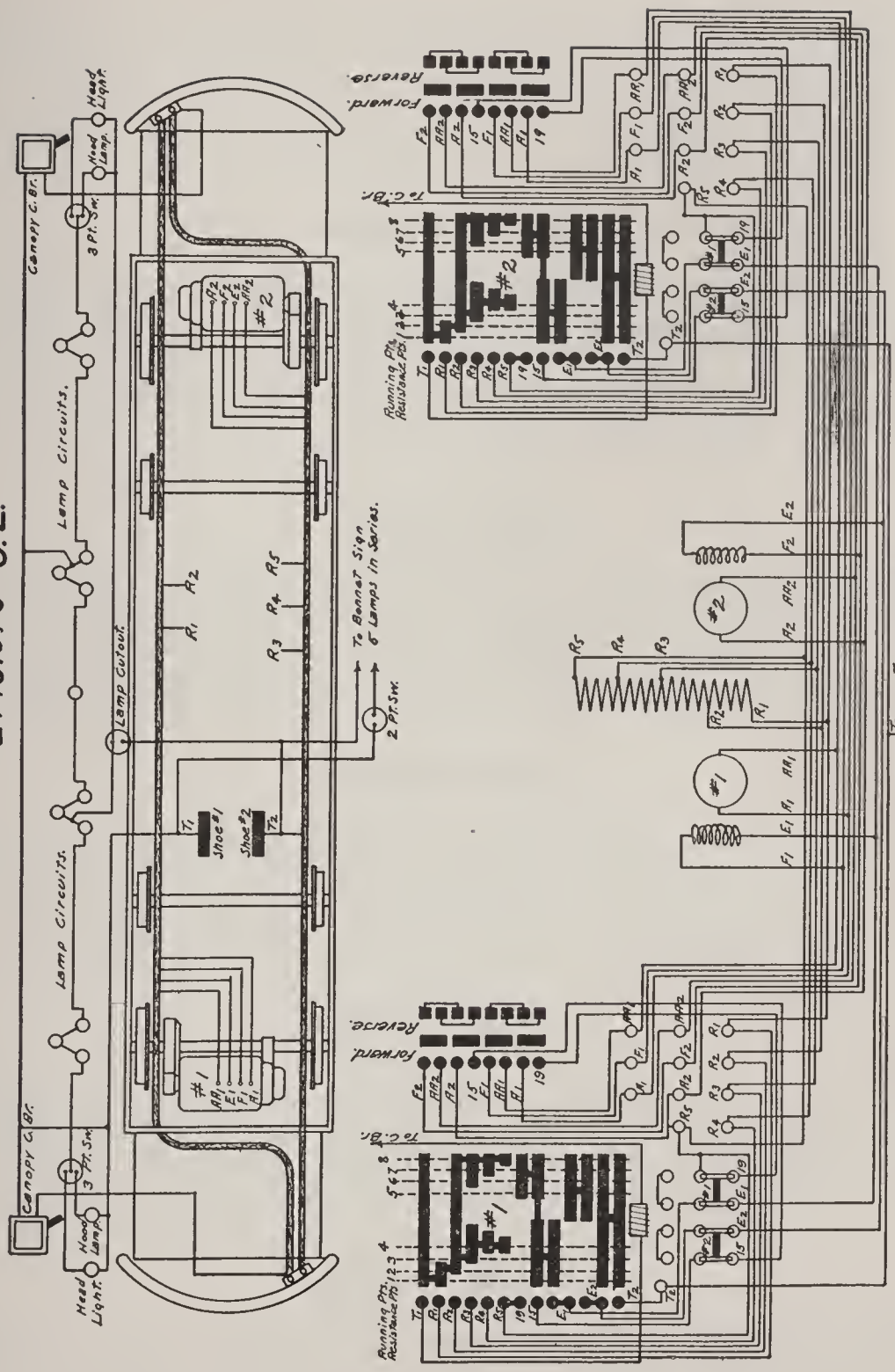

Car Wiring for 2-K27 Controllers
&
2 Motors G.E.
Canopy C. Br.
Hood Light.
Hood Lamp.
3 Pt. Sw.
Lamp Circuits.
Lamp Cutout.
To Bonnet Sign
& Lamps in Series.
2 Pt. Sw.
Shoe #1
Shoe #2
Forward.
Reverse.
To C. Br.
Running Pos.
Resistance Pts.
To C. Brs.

FIG. 16.

Third Position

When on the third position of controller, the circuit is the same as that of the second position, with this exception: the current enters rheostat at wire R–3, leaving at wire R–5.

Fourth Position

When on the fourth position of controller, the circuit is the same as that of the third position, with this exception: the two motors are in series without exterior resistance. This is known as a series safe running position.

Fifth Position

When on the fifth position of controller, the two motors are in a multiple connection with exterior resistance. The current entering rheostat at wire R–2, leaving at wire R–5.

Sixth Position

When on the sixth position of controller, the circuit is the same as that of the fifth position, with this exception: the current enters rheostat at wire R–3, leaving at wire R–5.

Seventh Position

When on the seventh position of controller, the circuit is the same as that of the sixth position, with this exception: the current enters rheostat at wire R–4, leaving at wire R–5.

Eighth Position

When on the eighth position of controller, the two motors are in a multiple connection without exterior resistance. This is known as the *parallel safe running position.*

G. E. K-12 CONTROLLER

This type of controller is constructed for a four-motor equipment. There are nine positions on controller, of which five are in series and four in parallel.

First Position

When on the first position of controller, the four motors are in a series multiple connection with exterior resistance. The current enters rheostat at wire R–1 and leaves at wire R–5.

Second Position

When on the second position of controller, the circuit is the same as that of the first position, with this exception: the current enters rheostat at wire R–2, leaving at wire R–5.

Third Position

When on the third position of controller, the circuit is the same as that of the second position, with this exception: the current enters rheostat at wire R–3, leaving at wire R–5.

Fourth Position

When on the fourth position of controller, the circuit is the same as that of the third position, with this exception: the current enters rheostat at wire R–4, leaving at wire R–5.

Fifth Position

When on the fifth position of controller, the circuit is the same as that of the fourth position, with this exception: the

four motors are in a series multiple connection without exterior resistance. This is known as the *series safe running position.*

Sixth Position

When on the sixth position of controller, the four motors are in a multiple connection with exterior resistance. The current enters rheostat at wire R–2, leaving at wire R–5.

Seventh Position

When on the seventh position of controller, the circuit is the same as that of the sixth position, with this exception: the current enters rheostat at wire R–3, leaving at wire R–5.

Eighth Position

When on the eighth position of controller, the circuit is the same as that of the seventh position, with this exception: the current enters rheostat at wire R–4, leaving at wire R–5.

Ninth Position

When on the ninth position of controller, the four motors are in a multiple connection without exterior resistance. This is known as the *parallel safe running position.*

MULTIPLE-UNIT SYSTEM

A Multiple Unit System allows of two or more motor units to be coupled for train operation. Each unit consists of a motor car equipped usually with two motors and their exterior resistance. A controlling device consisting of contactors for governing same for acceleration; the entire number of contac-

tors and their installation is called a contactor box or motor-controlling device. The contactors are operated by a master control circuit for establishing the various connections for motor circuit and exterior resistance circuit. Each motor car or unit is equipped with four third-rail shoes, together with the necessary wiring for motor rheostatic and trolley connections. Each unit has a bus and train line, composed of one or more wires, extending the entire length of car, terminating in coupler sockets for the purpose of forming connections for two or more cars. The bus line is a trolley line, and is so connected that providing only one third-rail shoe is in contact with the third rail, all other cars in train would be energized through this, for operation, where two or more cars constitute a train.

The bus line is made continuous through a jumper wire, connecting the two cars.

TRAIN LINE

The train line consists of a cable, having several wires, insulated one from the other, extending the entire length of car, and terminating with coupler sockets. This line is in connection with the master controller so that each individual unit can be operated automatically, from one master controlling device.

With this method of control, any individual unit can be dropped from circuit without interfering with other units in train operation.

Each motor unit is protected by circuit-breaker and fuses of each individual circuit, so that when an electrical defect presents itself, the fuse or circuit-breaker of that circuit will open same, preventing further trouble.

G. E. TYPE M CONTROL C-6 CONTROLLER

First Position or Step

When the master control cylinder is thrown on the first position or step, wire No. 8, which is in connection with the reversing switch and reverser operating coil, this being energized by trolley, sets reverser for forward direction of car, energizing wire No. 15 in diagram, completing its circuit through operating coil of contactor No. 1, leaving at wire No. 14, connecting with operating coil of contactor No. 2, leaving at wire No. 13, connecting with operating coil of contactor No. 3, leaving at wire No. 12, connecting with operating coil of contactor No. 11, leaving at wire No. 11, connecting with through interlock of contactor No. 12, to wire No. 1, which grounds to controlling cylinder of master controller, closing same. On this position the two motors are in a series position with exterior resistance.

Second Position or Step

The master control cylinder on the second position retains the same circuit as that of the first position, except that wire No. 3 is in circuit and energized.

Wire No. 3 connects with the operating coil of contactor No. 5, leaving at wire No. 32, to ground, and closing this contactor. On this position the two motors are in a series connection with a portion of exterior resistance cut-out.

Third Position or Step

The master control cylinder on the third position or step retains the same circuit as that of the second position or step,

with this exception: wire No. 3 being dropped from circuit, wire No. 4 being closed in circuit, connecting with four tubular

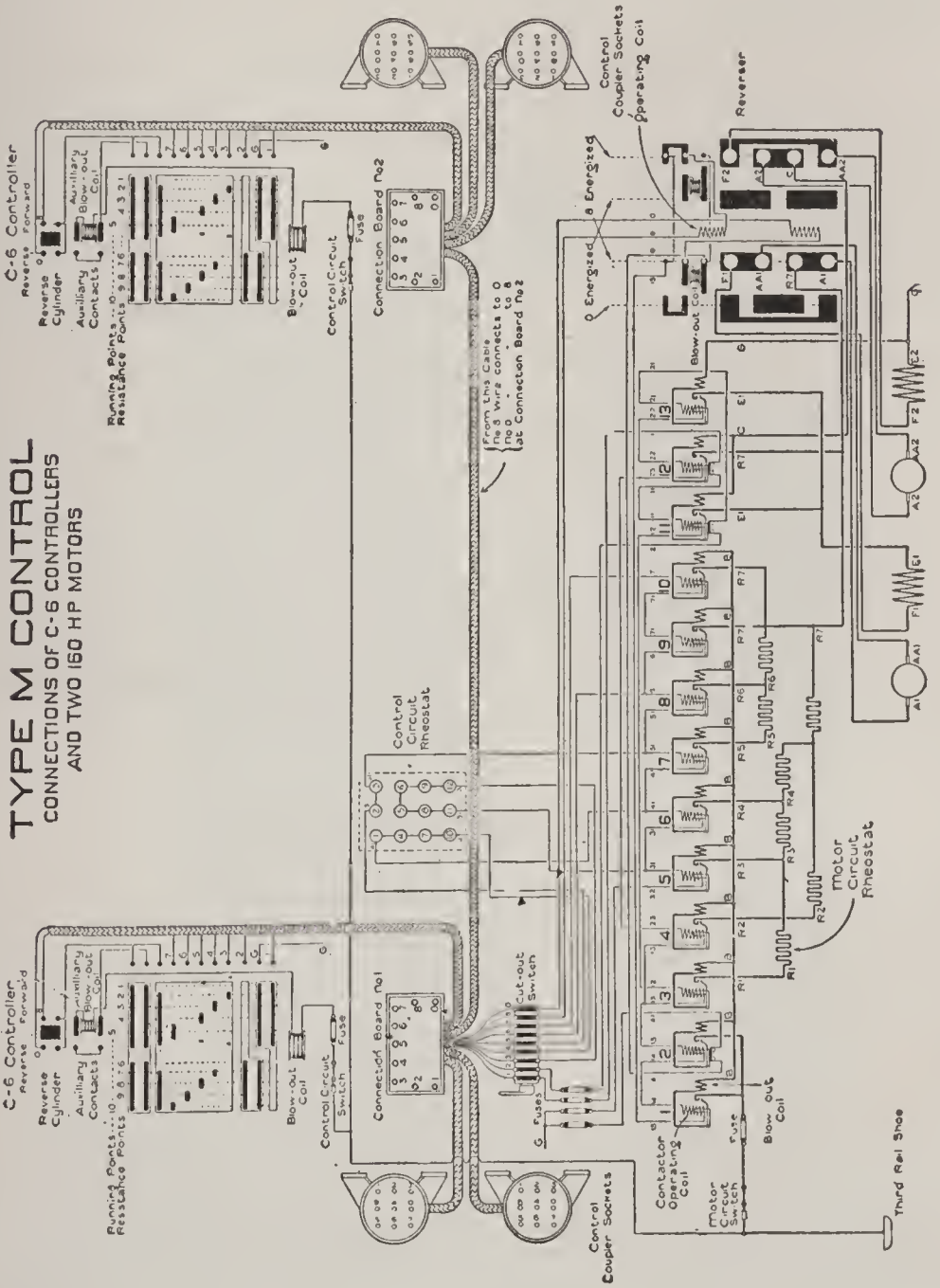


FIG. 17.

rheostatic tubes, leaving at wire No. 41, connecting with operating coil of contactor No. 6, leaving at wire No. 31, connecting with operating coil of contactor No. 5, leaving at wire No. 32

to ground, closing contactors Nos. 5 and 6. On this position the two motors are in a series connection with a portion of exterior existence being cut out.

Fourth Position or Step

The master control cylinder on the fourth position retains the same circuit as that of the third position, with this exception: wire No. 4 is dropped from the circuit, wire No. 5 is closed in circuit with two tubular rheostatic tubes, leaving at wire No. 51, connecting with operating coil of contactor No. 7, leaving at wire No. 41, connecting with operating coil of contactor No. 6, leaving at wire No. 31, connecting with operating coil of contactor No. 5, leaving at wire No. 32, to ground. Contactors Nos. 5 and 6 are retained by circuit of No. 5 wire; contactor No. 7 being closed on this circuit with wire No. 5. On this position the two motors are in a series connection with a portion of exterior resistance cut out.

Fifth Position or Step

The master control cylinder on the fifth position retains the same circuit as that of the fourth position, with this exception: wire No. 5 is dropped from circuit, wire No. 7 being closed in circuit, connecting with operating coil of contactor No. 10, leaving at wire No. 71, connecting with operating coil of contactor No. 9, leaving at wire No. 6, connecting with operating coil of contactor No. 8, leaving at wire No. 51, connecting with operating coil of contactor No. 7, leaving at wire No. 41, connecting with operating coil of contactor No. 6, leaving at wire No. 31, connecting with operating coil of contactor No. 5, leaving at wire No. 32, to ground. Contactors Nos. 5, 6, and 7

are retained by circuit of No. 7 wire; contactor No. 8 being closed with this circuit. On this position the two motors are in a series connection without exterior resistance, the current being direct to motor terminals.

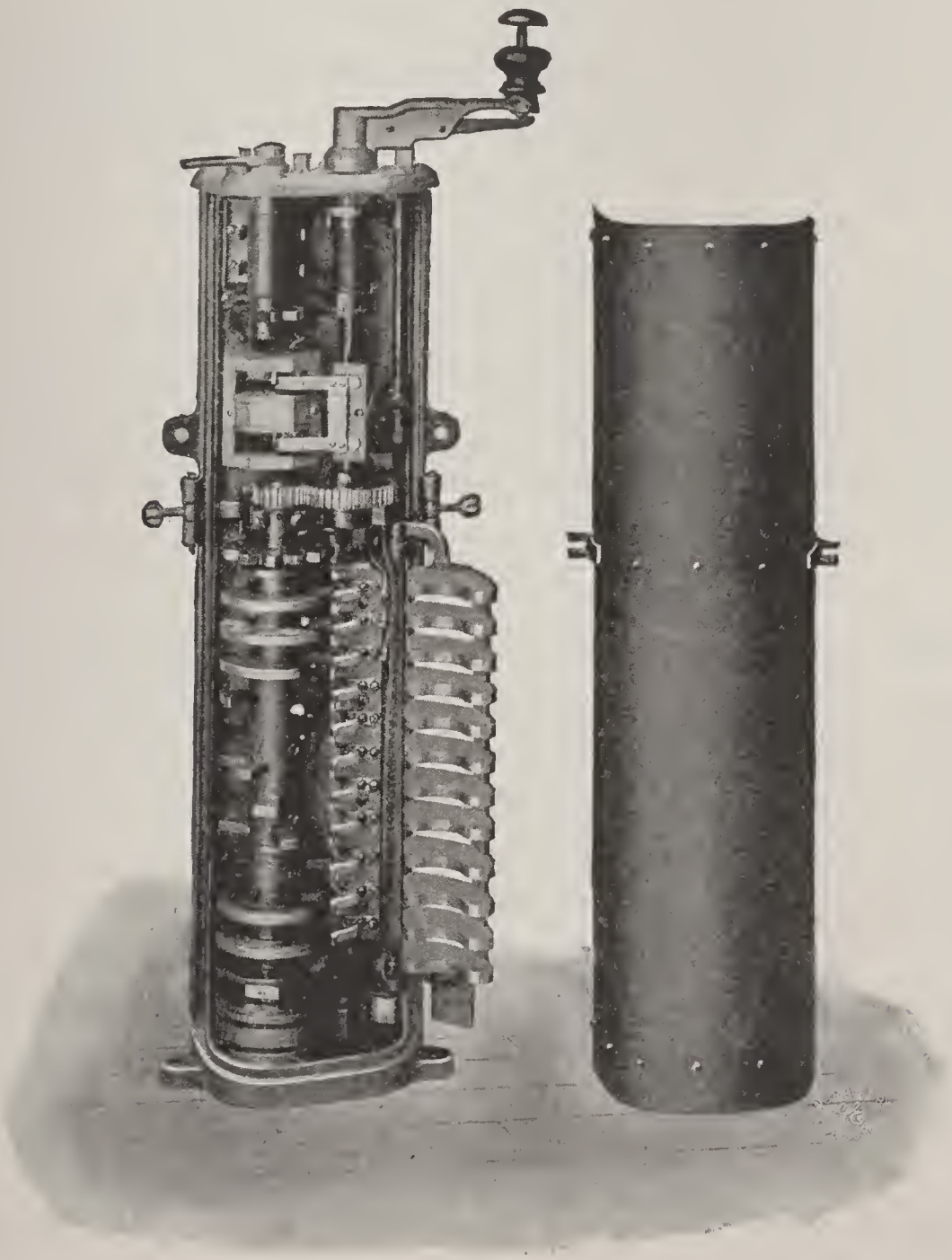


FIG. 18. — G. E. C.-6 Controller.

Sixth Position or Step

The master control cylinder on the sixth position or step closes the circuit of wire No. 2, which is a ground connection. Wire No. 1 is dropped from circuit. Wire No. 15 retains contactors Nos. 1 and 2 and closing contactors Nos. 4, 12, and 13. Wire No. 5 is closed in circuit, connecting with operating coil of contactor No. 1, leaving at wire No. 4, connecting with operating coil of contactor No. 2, leaving at wire No. 13, connecting with operating coil of contactor No. 4, leaving at wire No. 23, connecting with operating coil of contactor No. 12, leaving at wire No. 22, connecting with operating coil of contactor No. 13, leaving at wire No. 21, connecting with wire No. 2, through interlock of contactor No. 11, to ground. On this position the two motors are placed in parallel with exterior resistance.

Seventh Position or Step

When the master control cylinder is on the seventh position, the same circuit is retained as that of the sixth position, with this exception: wire No. 4 is closed in circuit, with four tubular rheostatic tubes, leaving at wire No. 41, connecting with operating coil of contactor No. 6, leaving at wire No. 31, connecting with operating coil of contactor No. 5, leaving at wire No. 32, to ground; closing contactors Nos. 5 and 6. On this position the two motors are in parallel with a portion of exterior resistance cut out.

Eighth Position or Step

When the master control cylinder is on the eighth position, the same circuit is retained as that of the seventh position, with

this exception: wire No. 4 is dropped from circuit, wire No. 5 is closed in circuit, connecting with two tubular rheostatic tubes, leaving at wire No. 51, connecting with operating coil of contactor No. 7, leaving at wire No. 41, connecting with operating coil of contactor No. 6, leaving at wire No. 3, connecting with operating coil of contactor No. 5, leaving at wire No. 32, to ground; closing contactor No. 7. On this position the two motors are in parallel with a portion of exterior resistance cut out.

Ninth Position or Step

When the master control cylinder is on the ninth position, the same circuit is retained as that of the eighth position, with this exception: wire No. 5 is dropped from circuit, wire No. 6 is closed in circuit, connecting with operating coil of contactor No. 8, leaving at wire No. 51, connecting with operating coil of contactor No. 7, leaving at wire No. 41, connecting with operating coil of contactor No. 6, leaving at wire No. 31, connecting with operating coil of contactor No. 5, leaving at wire No. 32, to ground; closing contactor No. 8. On this position the two motors are in parallel, with a portion of exterior resistance cut out.

Tenth Position or Step

When the master control cylinder is on the tenth position, the same circuit is retained as that of the ninth position, with this exception: wire No. 6 being dropped from circuit, wire No. 7 is closed in circuit, connecting with operating coil of contactor No. 10, leaving at wire No. 71, connecting with operating coil of contactor No. 9, leaving at wire No. 6, connecting with op-

erating coil of contactor No. 8, leaving at wire No. 51, connecting with operating coil of contactor No. 7, leaving at wire No. 41, connecting with operating coil of contactor No. 6, leaving at wire No. 31, connecting with operating coil of contactor No. 5, leaving at wire No. 32, to ground. On this position the two motors are in parallel, without exterior resistance.

MOTOR CIRCUIT IN CONNECTION WITH G. E. TYPE M CONTROL C-6 CONTROLLER

DIRECTION OF CURRENT

First Position

From third-rail shoe to main switch, to main fuse, to circuit-breaker, to contactors Nos. 1, 2, and 3, through wire R–1, connecting with rheostatic circuit, leaving at wire R–7, connecting with reverser. When reverser is thrown for motor connections, wire R–7 is placed in connection with wire A–1, connecting with brush-holder of armature circuit of No. 1 motor, passing through armature circuit, leaving at opposite brush-holder through wire AA–1, connecting with reverser, leaving at wire F–1, connecting with field circuit of No. 1 motor, consisting of two or four fields in a series connection, leaving at wire E–1, connecting with contactor No. 11, leaving at wire C, connecting with reverser, leaving at wire A–2, connecting with brush-holder of armature circuit of motor No. 2, passing through armature circuit, leaving at opposite brush-holder through wire AA–2, connecting with reverser, leaving at wire F–2, connecting with field circuit of motor No. 2, consisting of two or four fields in a series connection, leaving at wire E–2, connecting with main ground wire. On this position the

motors are in series, having in circuit four blocks of exterior resistance.

Second Position

On this position the motor circuit is the same as that of the first position, with this exception: a part of the resistance is dropped from circuit by the closing of contactor No. 5. On this position there are three blocks of exterior resistance in series with the two motors.

Third Position

On this position the circuit is the same as that of the second position, with this exception: a part of the resistance is dropped from circuit by the closing of contactor No. 6. The current entering the rheostatic circuit through wire R–4. On this position the motors are in series, having in circuit two blocks of exterior resistance.

Fourth Position

On this position the circuit is the same as that of the third position, with this exception: a part of the resistance is dropped from circuit by the closing of contactor No. 7. The current entering the rheostatic circuit through wire R–5. On this position the motors are in series, having in circuit one block of exterior resistance.

Fifth Position

On this position the circuit is the same as that of the fourth position, with this exception: all exterior resistance being cut

out by the closing of contactors Nos. 8, 9, and 10. The current leaving contactor No. 9, through wire No. 7, for motor circuit. On this position the motors are in series, the current being direct to motor terminals.

Sixth Position

On this position the motors are in a parallel connection; the current leading from the third-rail shoe to main switch, to main fuse, to circuit-breaker, connecting with contactors Nos. 1, 2, and 4, leaving contactor No. 4, through wire R–2, for No. 1 motor's circuit, connecting with two blocks of resistance, leaving same at wire R–7, connecting with reverser, leaving at wire A–1, connecting with brush-holder of armature circuit of No. 1 motor, passing through armature circuit, leaving at armature brush-holder through wire AA–1, connecting with reverser, leaving at wire F–1, connecting with field circuit of No. 1 motor, consisting of two or four fields in series connection, leaving at wire E–1, connecting with contactor No. 13, to ground. Also, wire R–7 connects with contactor No. 12, the current leaving at wire C, connecting with reverser, for No. 2 motor's circuit, leaving at wire A–2, connecting with brush-holder of armature circuit of motor No. 2, passing through armature circuit, leaving at opposite brush-holder through wire AA–2, connecting with reverser, leaving at wire F–2, connecting with field circuit of motor No. 2, consisting of two or four fields in a series connection, leaving at wire E–2, connecting with main ground wire. On this position the motors are in parallel, having in circuit two blocks of exterior resistance.

Seventh Position

On this position the motor circuits are the same as that of the sixth position, with this exception: a part of the resistance is dropped from circuit, by closing contactors Nos. 5 and 6. The current entering the rheostatic circuit through wires R–3 and R–4, leaving at wire R–7, connecting with reverser, for circuits of motor No. 1 and No. 2. On account of the shunt connection, the current leaves contactor No. 6 for rheostatic circuit. On this position the two motors are in parallel, having still in circuit two blocks of exterior resistance.

Eighth Position

On this position the motor circuits are the same as those of the seventh position, with this exception: a part of the resistance is dropped from circuit by closing contactor No. 7. The current entering the rheostatic circuit through wires R–3, R–4, and R–5, leaving at R–7, connecting with reverser, for circuits of motors Nos. 1 and 2. On account of the shunt connection, the current leaves contactor No. 7, through wire R–5, for rheostatic circuit. On this position the two motors are in parallel, having in circuit two blocks of exterior resistance.

Ninth Position

On this position the motor circuits are the same as those of the eighth position, with this exception: a part of the resistance is dropped from circuit by closing contactor No. 8. The current entering the rheostatic circuit through wires R–3, R–4, and R–6, leaving at R–7, connecting with reverser, for circuits of motors Nos. 1 and 2. On account of the shunt connection,

the current leaves contactor No. 8, through wire R–6, for rheostatic circuit. On this position the two motors are in parallel, having in circuit one block of exterior resistance.

Tenth Position

On this position the motor circuits are the same as those of the ninth position, with this exception: the entire rheostatic circuit is dropped by the closing of contactors Nos. 9 and 10. The current leaving contactor No. 10, through wire R–7, connecting with reverser for circuits of motors Nos. 1 and 2. On this position the two motors are in parallel, with current direct to motor terminals. The safe running positions are 5 and 10, the unsafe running positions are 1, 2, 3, 4, 6, 7, 8 and 9, on account of having exterior resistance in circuit.

THE SPRAGUE G. E. MASTER CONTROLLER TYPE C-35

The type C–35 controller consists of a cylinder mounted with cylinder contact plates or segments. These are divided into four sections, each section being insulated from the others, and containing two segments, excepting the top section, which has three. At the right hand of cylinder are installed ten contact fingers, which are in connection with trolley and operating circuit wires. The top contact finger is in connection with wire No. 1, which is known as the accelerating wire. The second contact finger down from top of controller is in connection with wire No. 2, which is known as the series wire and also a retaining wire for certain contactors. The third contact finger down from top of controller is trolley for wire Nos. 1 and 2. The fourth contact wiper down from top of

controller is in connection with wire No. 3, which is known as the parallel wire. The fifth contact finger down from top of controller is trolley for wire No. 3. The sixth contact finger down from top of controller is main trolley. The seventh

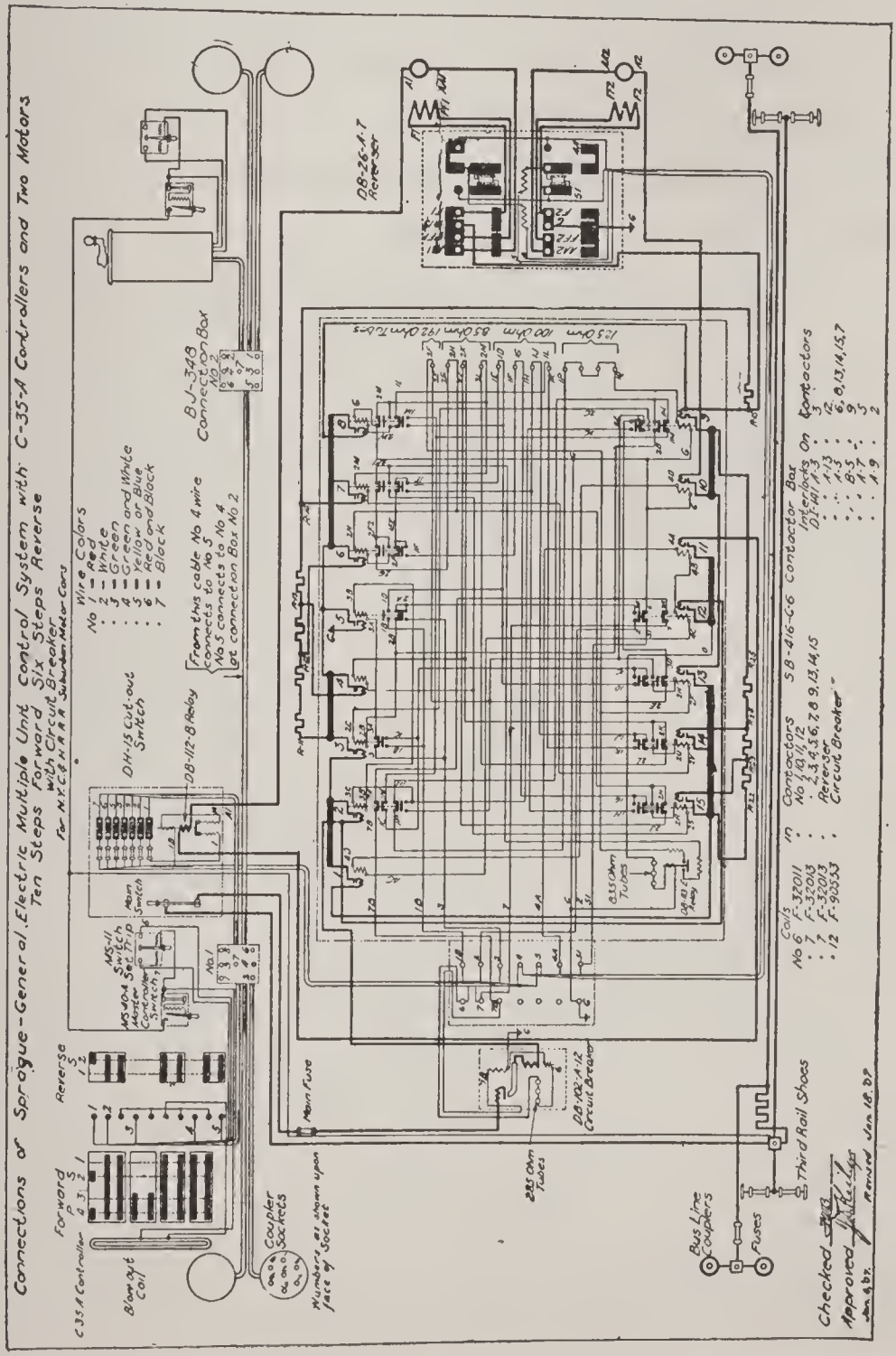


FIG. 19.

contact finger down from top of controller is trolley connection for wires 1, 2, 3, and 4. The eighth contact finger down from top of controller is in connection with wire No. 4, which is reverser wire for forward direction; also closing contactors 11, 12, 1 and 10 for operation. The ninth contact finger down from top of controller is the trolley connection for wire No. 4. The tenth contact finger down from top of controller is in connection with wire No. 5, which sets reverser for backward motion and closes contactors 11, 12, 1, and 10.

First Position. Series Lap Position

When controlling cylinder is on first position, wires Nos. 4 and 2 are energized. Wire No. 4 is in connection with operating coil of reverser, setting same for forward direction of car. The negative terminal of operating coil is in connection with wire 4–A which connects with operating coil of contactor No. 11, leaving at wire 4–B, connecting with operating coil of contactor No. 12, leaving at wire 4–C, connecting with operating coil of contactor No. 1, leaving at wire 4–D, connecting with operating coil of contactor No. 10, to ground. Wire No. 2 connects with wire 2–A, through interlock of contactor No. 12, connecting with interlock of contactor No. 5, leaving at wire 2–B, connecting with operating coil of contactor No. 3, which is the series contactor, leaving at wire 2–C, connecting with interlock of contactor No. 9, leaving at wire 2–E, connecting with a 192-ohm tube of resistance, leaving at wire 2–F through interlock of D. B. 113 relay, leaving at wire 2–F–1, connecting with interlock of contactor No. 7, leaving at wire 2–F–2, connecting with interlock of contactor No. 6, leaving at wire 2–G, connecting with an 85-ohm tube of resist-

ance, leaving at wire 2–H, connecting with interlock of contactor No. 15, leaving at wire 2–J, connecting with an 85-ohm tube of resistance, leaving at wire 2–K, connecting with interlock of contactor No. 14, leaving at wire 2–L, connecting with an 85-ohm tube of resistance, leaving at wire 2–M, connecting with interlock of contactor No. 8, to ground.

Series Position. First Step

When controlling cylinder is on the series position, wires Nos. 4 and 2 retain the same circuit as on the first position. On this position wire No. 1 is energized, which connects with blow-out coils of D. B 112 relay, leaving at wire 1–B, connecting with interlock of contactor No. 3, leaving at wire 1–C, connecting with interlock and operating coil of contactor No. 13, leaving at wire 2–N, which connects with wire 2–F through interlock of D. B. 113 relay, leaving at wire 2–F–1, connecting with interlock of contactor No. 7, leaving at wire 2–F–2, connecting with interlock of contactor No. 6, leaving at wire 2–B, connecting with an 85-ohm tube of resistance, leaving at wire 2–H, connecting with interlock of contactor No. 15, leaving at wire 2–J, connecting with an 85-ohm tube of resistance, leaving at wire 2–K, connecting with interlock of contactor No. 14, leaving at wire 2–L, connecting with an 85-ohm tube of resistance, leaving at wire 2–M, connecting with interlock of contactor No. 8, to ground.

Second Step

On this step a new circuit is established for wire No. 1. Wire 1–B connects with wire 1–C, through interlock of contac-

tor No. 3, connecting with wire 1–D, through interlock of contactor No. 13 to wire 1–E, connecting with a 100-ohm tube of resistance, leaving at wire 1–E, connecting with interlock of contactor No. 7, leaving at wire 1–EE, connecting with wire 2–P, connecting with interlock of contactor No. 6, also connecting with operating coil of contactor No. 6, closing same; leaving at wire 2–H through circuit of No. 2 wire to ground.

Third Step

Wire 1–B connects with wire 1–C, through interlock of contactor No. 3, connecting with wire 1–D, through interlock of contactor No. 13. Wire 1–D connects with wire 1–E, through a 100-ohm tube of resistance, connecting with wire 1–EE, connecting with interlock of contactor No. 7, connecting with wire 1–F, through interlock of contactor No. 6, connecting with wire 1–G, through a 100-ohm tube of resistance, connecting with interlock of contactor No. 15, which connects with operating coil of contactor No. 15 through wire 2–R, leaving at wire 2–S, connecting with operating coil of contactor No. 4, leaving at wire 2–K, connecting with interlock of contactor No. 14, leaving at wire 2–L, connecting with an 85-ohm tube of resistance, leaving at wire 2–M, connecting with interlock of contactor No. 8, to ground.

Fourth Step

On this step a new circuit is established for closing contactors 14 and 7, with wire No. 1. Wire 1–B connects with wire 1–C through interlock of contactor No. 3, which connects with interlock of contactor No. 13, leaving at wire 1–D, which

connects with a 100-ohm tube of resistance, leaving at wire 1–E, connecting with interlock of contactor No. 7, leaving at wire 1–EE, connecting with interlock of contactor No. 6, leaving at wire 1–F, connecting with a 100-ohm tube of resistance, leaving at wire 1–G, connecting with interlock of contactor No. 15, leaving at wire 1–H, connecting with a 100-ohm tube of resistance, leaving at wire 1–J, connecting with interlock of contactor No. 14, leaving at wire 2–U, connecting with operating coil of contactor No. 14, leaving at wire 2–V, connecting with operating coil of contactor No. 7, leaving at wire 2–M, to ground.

Fifth Step

On this step a circuit is established for closing contactor No. 8, with wire No. 1. Wire 1–B connects with interlock of contactor No. 3, leaving at wire 1–C, connecting with interlock of contactor No. 13, leaving at wire 1–D, connecting with a 100-ohm tube of resistance, leaving at wire 1–E, connecting with interlock of contactor No. 7, leaving at wire 1–H, connecting with a 100-ohm tube of resistance, leaving at wire 1–J, connecting with interlock of contactor No. 14, leaving at wire 1–K, connecting with a 100-ohm tube of resistance, leaving at wire 1–L, connecting with interlock of contactor No. 8, leaving at wire 2–W, connecting with operating coil of contactor No. 8, to ground.

Sixth Step

On this step a new circuit is established for closing contactor No. 9, with wire No. 1. Wire 1–B connects with interlock of contactor No. 3, leaving at wire 1–C, connecting with interlock of contactor No. 13, leaving at wire 1–D, connecting

with interlock of contactor No. 8, leaving at wire 1–M, connecting with interlock of contactor No. 9, leaving at wire 1–N, connecting with interlock of contactor Nos. 2, leaving at wire 1–P, connecting with four 125-ohm tubes of resistance in a series connection, leaving at wire 1–Q, connecting with operating coil of contactor No. 9, to ground.

Note: When contactor No. 9 closes, contactors Nos. 3, 4, 6, 7, 8, 13, and 14 open.

7-A Position or Parallel Lap Position

On this position contactors Nos. 2 and 5 are closed for parallel connections by wire No. 3. Contactors Nos. 1, 10, 11, and 12 are retained by wire No. 4. Wire No. 2 is retaining wire for contactors on all parallel steps. Contactor No. 2 is a trolley connection for No. 2 motor's circuit; contactor No. 5 is ground for No. 1 motor's circuit.

Wire No. 3 connects with interlock of contactor No. 3, leaving at wire 3–A, connecting with operating coil of contactor No. 5, leaving at wire 3–B, connecting with operating coil of contactor No, 2, leaving at wire 3–C, connecting with interlock of contactor No. 9, leaving at wire 3–D, connecting with interlock of contactor No. 13, leaving at wire 2–E, connecting with a 192-ohm tube of resistance, leaving at wire 2–F, connecting with interlock of D. B. 113 E relay, leaving at wire 2–F–1, connecting with interlock of contactor No. 7, leaving at wire 2–F–2, connecting with interlock of contactor No. 6, leaving at wire 2–G, connecting with an 85-ohm tube of resistance, leaving at wire 2–H, connecting with interlock of contactor No. 15, leaving at wire 2–J, connecting with an 85-ohm tube of resistance, leaving at wire 2–K, connecting with inter-

lock of contactor No. 14, leaving at wire 2–L, connecting an 85-ohm tube of resistance, leaving at wire 2–M, connecting with interlock of contactor No. 8, to ground.

Seventh Step

On this step wire No. 1 is energized, closing contactor No. 6. Wire 1–B connects with interlock of contactor No. 5, leaving at wire 1–D, connecting with a 100-ohm tube of resistance, leaving at wire 1–E, connecting with interlock of contactor No. 7, leaving at wire 1–EE, connecting with interlock of contactor No. 6, leaving at wire 2–P, connecting with operating coil of contactor No. 6, leaving at wire 2–H, through circuit of No. 2 wire, to ground.

Eighth Step

On this step a new circuit is established for closing contactors Nos. 15 and 4 with wire No. 1. Wire 1–B connects with interlock of contactor No. 5, leaving at wire 1–D, connecting with a 100-ohm tube of resistance, leaving at wire 1–E, connecting with interlock of contactor No. 7, leaving at wire 1–EE, connecting with interlock of contactor No. 6, leaving at wire 1–F, connecting with a 100-ohm tube of resistance, leaving at wire 1–G, connecting with interlock of contactor No. 15, leaving at wire 2–R, connecting with operating coil of contactor No. 15, leaving at wire No. 2–S, connecting with operating coil of contactor No. 4, leaving at wire 2–K, through circuit of No. 2 wire, to ground.

Ninth Step

On this step a circuit is established for closing contactors Nos. 14 and 7 with wire No. 1. Wire 1–B connects with inter-

lock of contactor No. 5, leaving at wire 1–D, connecting with a 100-ohm tube of resistance, leaving at wire 1–E, connecting with interlock of contactor No. 7, leaving at wire 1–EE, connecting with interlock of contactor No. 6, leaving at wire 1–F, connecting with a 100-ohm tube of resistance, leaving at wire 1–G, connecting with interlock of contactor No. 15, leaving at wire 1–H, connecting with a 100-ohm tube of resistance, leaving at wire 1–J, connecting with interlock of contactor No. 14, leaving at wire 2–U, connecting with operating coil of contactor No. 14, leaving at wire 2–V, connecting with operating coil of contactor No. 7, leaving at wire 2–M, connecting with interlock of contactor No. 8, to ground.

Tenth Step

Wire 1–B connects with interlock of contactor No. 5, leaving at wire 1–D, connecting with a 100-ohm tubes of resistance, leaving at wire 1–E, connecting with interlock of contactor No. 7, leaving at wire 1-H, connecting with a 100-ohm tube of resistance, leaving at wire 1–J, connecting with interlock of contactor No. 14, leaving at wire 1–K, connecting with a 100-ohm tube of resistance, leaving at wire 1–L, connecting with interlock of contactor No. 8, leaving at wire 2–W, connecting with operating coil of contactor No. 8, to ground.

Note: Contactor No. 13 closes after 8 has closed.

Wire 1–B connects with interlock of contactor No. 5, leaving at wire 1–D, connecting with interlock of contactor No. 8, leaving at wire 1–M, connecting with interlock of contactor No. 2, leaving at wire 1–C, connecting with interlock of contactor No. 13, leaving at wire 2–N, connecting with operating

coil of contactor No. 13, leaving at wire 2–F, through circuit of No. 2 wire, to ground.

MOTOR CIRCUIT

First Position

On this position the two motors are in series with full exterior resistance.

Second Position

On this position the two motors are in series with exterior resistance; three blocks of resistance being cut out by contactor No. 13.

Third Position

On this position the two motors are in series with exterior resistance of No. 1 motor's circuit, one rheostatic block being dropped out by contactor No. 6.

Fourth Position

On this position the two motors are in series with exterior resistance, having an additional block of resistance cut out by contactor No. 4.

Fifth Position

On this position the two motors are in series with exterior resistance of No. 1 motor's circuit, having an additional block of resistance cut out by contactor No. 7.

Sixth Position

On this position the two motors are in series without exterior resistance, being cut out by contactor No. 8.

6-A Position

On this position the two motors are in series without exterior resistance, the series connection being held by contactor No. 9.

7-A Position

On this position the two motors are in parallel with exterior resistance for each individual motor circuit.

Seventh Position

On this position the two motors are in a parallel connection with one block of resistance cut out by contactor No. 6.

Eighth Position

On this position the two motors are in a parallel connection, having one block of resistance cut out on each motor's circuit by contactors Nos. 15 and 4.

Ninth Position

On this position the two motors are in a parallel connection, having an additional block of resistance cut out on each motor's circuit by contactors Nos. 14 and 7.

Tenth Position

On this position the two motors are in a parallel connection without exterior resistance, it being cut out by contactors Nos. 8 and 13.

WESTINGHOUSE UNIT SWITCH GROUP CONTROL

The contactor type of controller employed is known as the Unit Switch Group Control, a complete controlling equipment of this type, for one car, consisting of one Unit Switch Group, one line switch, one reverse switch, two motorman's multiple-control switches, one limit switch, one line relay switch, one set of seven point connectors and fourteen cells of storage battery.

The Unit Switch Group consists of a number of independent or "unit" switches grouped together radially about a central reservoir and operated by small pneumatic cylinders, the valves of which are controlled by electro-magnets. The magnet valves which control the several unit switches are so interconnected by simple mechanical interlock switches that the closing of one energizes the magnet of the switch next succeeding. The automatic progressive action thus provided is regulated by the "limit switch" so adjusted that the various switches are successively closed to afford a uniform acceleration with a constant motor current. The rate of acceleration is determined by the adjustment of the "limit switch," the magnet of which is connected in series with the motor circuit so that the switch is opened and the progressive action of the unit switches arrested whenever the motor current reaches a predetermined amount for which the limit switch has been adjusted.

As soon as the motor current falls below this amount the switch closes, and the progressive action of the unit switches is continued.

The "line relay" is a switch placed in the operating circuit, the function of which is to protect the motors from an abnormal

rush of current in case the main line circuit is suddenly re-established after interruption.

The "reverse switch" consists of an insulating block, mounted on a horizontal shaft, which carries two sets of metal

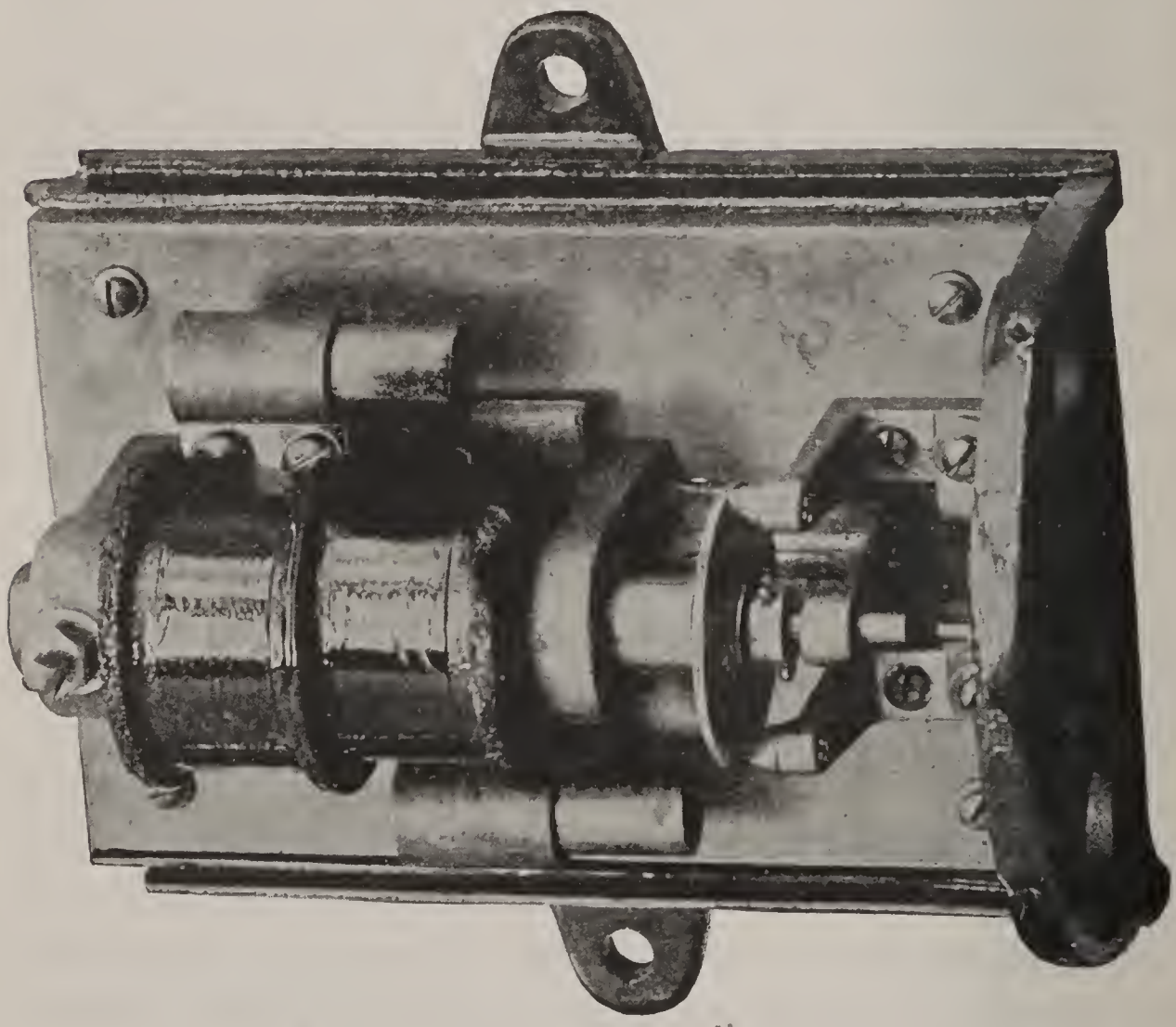


FIG. 20. — W. H. Current Limit Relay.

strips arranged to make contact with stationary fingers, which is operated forward and back in a simple straight-line motion by the pistons of two pneumatic cylinders. These cylinders are controlled by electro-magnetic valves, which are in turn governed by the controller.

Fig. 20*a* shows diagrammatically the wiring and connections of the electro-magnetic valves, interlocks, and switches of one car equipped with Unit Switch Group type of contact. In following out on this diagram the various circuits and cycles of

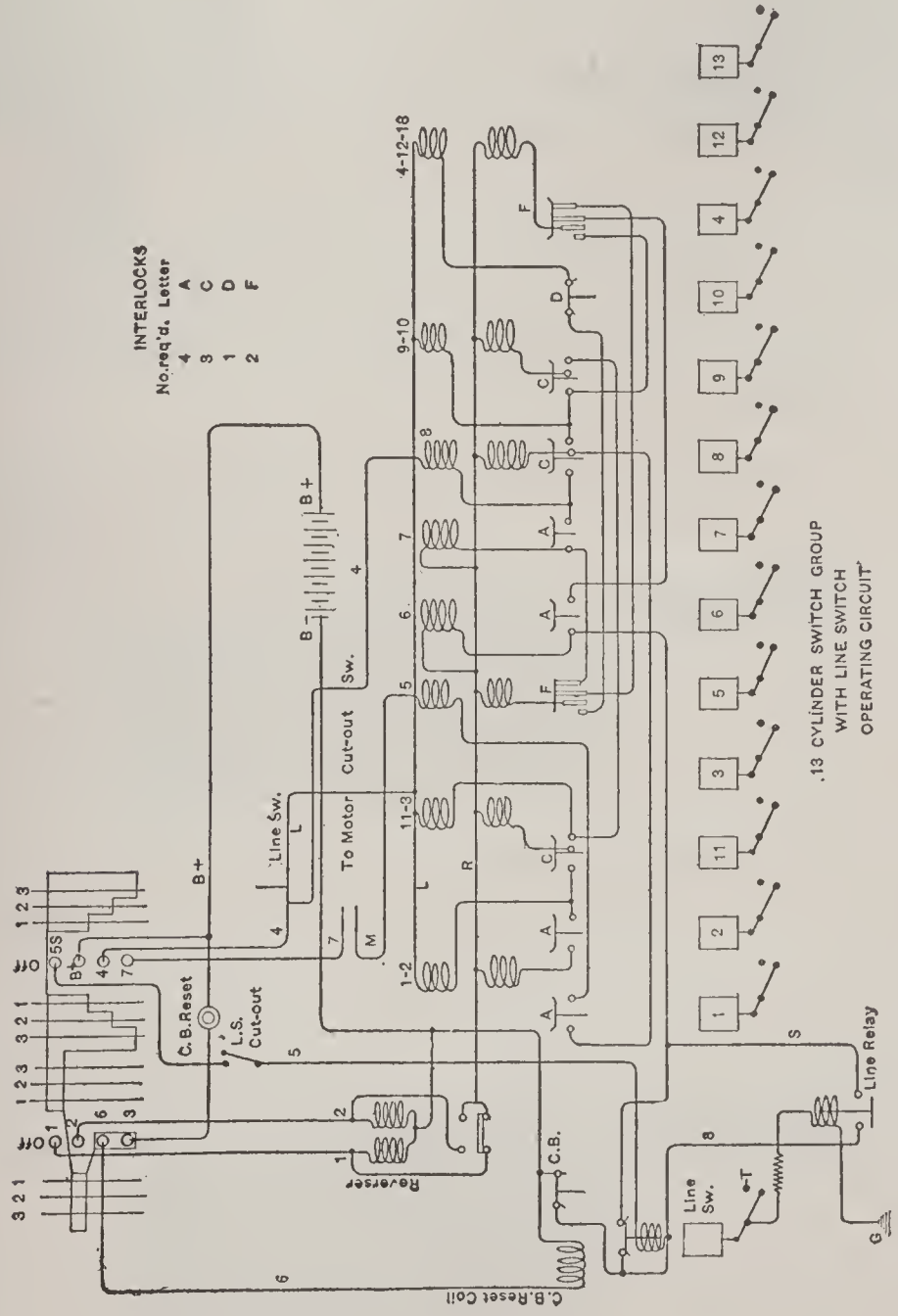


FIG. 20*a*.

operation it will be well to remember that, as in the drum type of control, all of the contacts on the drum of the multiple-control switch are electrically one, and that the function of this switch is to connect the low-voltage magnet circuits to the positive of the battery. All of the magnets, with the exception of the limit-switch magnet, and line-relay magnet, have one terminal connected to the common return B—, which is in turn connected to the negative terminal of the battery.

When the multiple-control switch is moved to the right so that the point marked 1 on the drum development corresponds with the stationary contacts, there is no circuit completed, hence no operation resulting.

When the multiple-control switch drum is moved to position 2, 6 and 2 are connected to B+, thus completing the battery circuit through the line-switch magnet and through the forward reverse magnet. The line-switch magnet opens the valve admitting air to the line-switch cylinder, the piston of which closes line switch. The reverse magnet opens the valve which admits air to one of the reverse cylinders, throwing the reverser contacts to the "ahead" position. A circuit is then completed across the reverse interlock, between 2 and R, through the magnet of No. 6 switch, No. 6 switch closing, thence across No. 6 interlock through magnet of No. 7 switch. No. 7 switch closing completes the main line circuit through the motors with full resistance. This is known as the "switching notch" and should be used for coupling only.

Upon moving the switch drum to position 3, the battery circuit is completed through the magnet of No. 8 switch and across the limit switch to magnets 9 and 10, 11 and 3, and

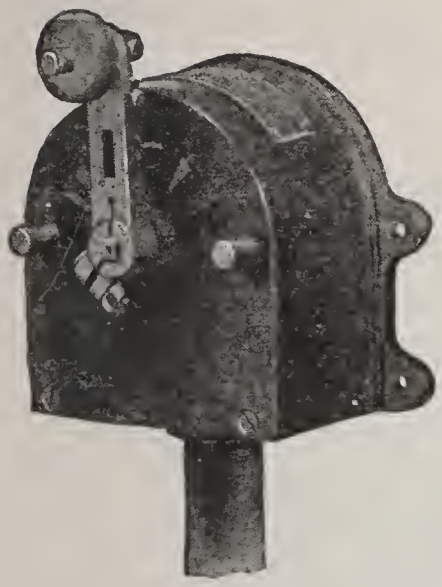


FIG. 20*b*. — Unit Control Switch (closed).

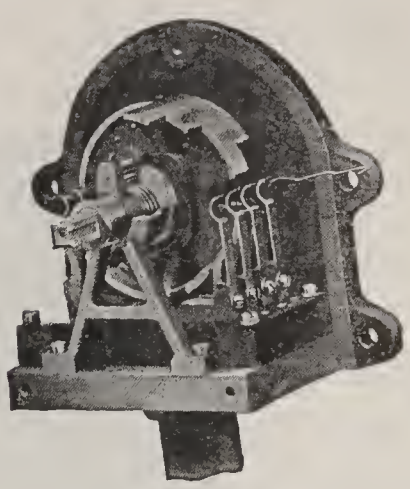


FIG. 20*c*. — Unit Control Switch.

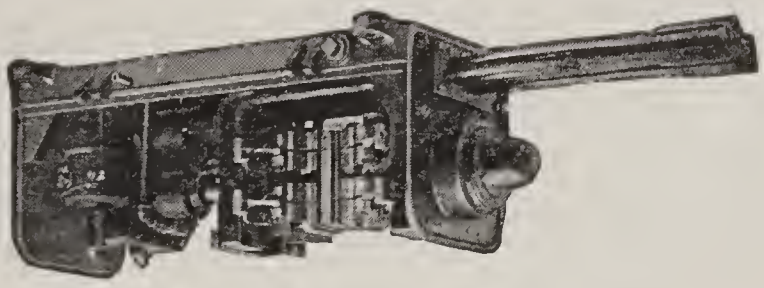


FIG. 20*d*. — Reverse Switch (open).

FIG. 20*e*. — Reverse Switch (closed).

1 and 2, these switches closing in the order given when full series is reached.

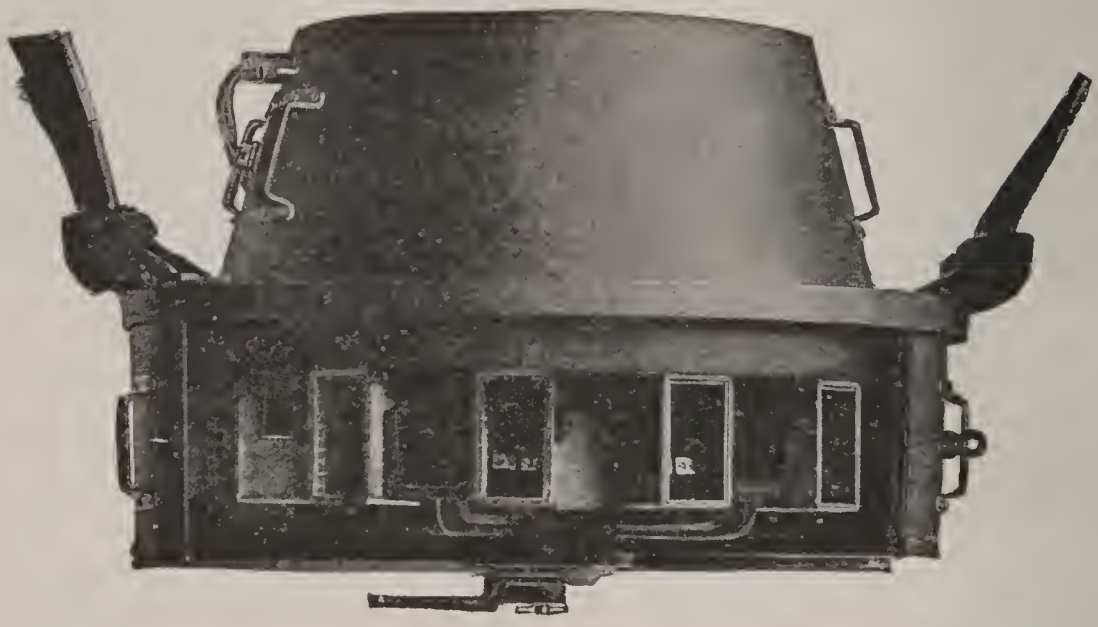


FIG. 20*f*. — W. H. Muett Contactor Box.

Upon moving the multiple-control switch handle to position No. 4, connection is established between B+ and No. 7 wire, thus completing circuit through magnet of No. 5 switch. This switch closing maintains the main motor circuit in full series

FIG. 20*g*. — Coupler Sockets.

and drops out or opens all switches that have previously come in with the exception of Nos. 6 and 8, which are still held closed.

The circuit of magnet for switches Nos. 4, 12, and 13 is then completed across No. 7 interlock. These switches closing form the multiple connection of main motor circuit, No. 5 switch dropping out or opening. The circuits are then once more completed through magnets of 9 and 10, 11 and 3, and 1 and 2 switches, these switches again closing when full multiple is reached.

To throw off the controller the multiple-control switch handle should be brought to position 1, thus breaking all operating circuits and opening all switches of Unit Switch Group and line switch.

It should be understood that in the foregoing the magnets have simply opened valves, allowing air to pass into the cylinders of the various switches, compressed air being the force employed for closing of the switches.

It will be noted that two sets of batteries are used. This is done so that one set may be charged while the other is discharging. The batteries are charged by throwing one set at a time in series with the light circuit. This is accomplished by means of two double-pole double-throw switches so connected that they are thrown both up or both down to change from one set of batteries to the other.

Getting Train Ready for Service

First start air pumps on all motor cars in train and allow the same to pump up to the full pressure for which the governors are set.

Put on brake and operating box handle, placing the former at "release" and the latter in the middle position.

Go through the train and see that (1) all plugs between

cars are in their sockets properly, (2) the air hose is coupled, (3) all cut-out cocks leading to the train pipe are open, and (4) the hand brakes are off.

If the air train pipe and multiple unit train line are all right, open the air-cocks F-A and F-B leading to the controllers and circuit-breaker on the several cars of the train, and close both battery switches (CC′), taking care to throw both of them either up or down.

Operation of Train

To start the train, first make sure that the brakes are released and the brake handle in the release position, then press the latch in operating switch handle and bring the handle to position No. 1, on the right if it is desired to move ahead, or on the left if it is desired to back up. This is a preparatory motion and merely admits air to the breaker cylinder on each car, compressing the throw-out spring, and throwing in the circuit-breaker.

Next move the handle slowly to position No. 3, *i.e.*, against the projecting notch; this will throw all the reserve switches on the train to the forward or back position, as the case may be, exhaust the air from the release cylinder and admit air to operating cylinder.

The controller on all the cars in the train will now notch up automatically one step at a time until full series position is reached, when they will stop.

To throw the controller to full multiple, press the latch in operating handle and bring the handle to position No. 4, *i.e.*, down against the brass pin. The controllers will now notch up automatically to the full "on" position.

The rate at which the controllers will notch up is governed by the limit switch. This switch is connected across the field of one of the motors and arranged so that when the current through the motors exceeds a certain amount the automatic action of the controllers is stopped and does not start again until the current falls once more below the limit.

The limit switch on all cars should be set by the person properly authorized to do the same for a fixed maximum, and should not be tampered with in any way by the motorman.

To throw the controllers off, bring the operating handle to position No. 1.

The controller may be stopped at any point while it is notching up by simply bringing the operating handle back to position No. 2. It should be remembered, however, that full series and full multiple are the only running positions for the controller, and it should not be allowed to stand on intermediate points for more than a short time.

When the controllers are on points between, "full series" and "full multiple" resistances are interposed in the motor circuits, and if these are allowed to remain in circuit they are liable to be burned out.

Should the circuit-breaker on any car in the train come out while running, throw the controllers off by bringing the handle to position No. 1. This will reset the circuit-breakers.

WHAT TO DO IN CASE OF TROUBLE

Open-circuited Motors

When you find that one of the motors is not working, have your conductor get off the car and while you apply the power let him watch to see which motor is working, which he can easily tell by the spinning of the wheels, then cut out the defective motor so as to get power on the first position.

When operating with a K or K–1 controller, and No. 1 motor is open-circuited, the car cannot be operated until the fifth or first parallel position is reached. When the open circuit is located in No. 2 motor's circuit, No. 1 motor can be operated when the controlling cylinder is in position midway between the fourth and fifth positions.

When operating with a type K–2 controller and No. 1 motor is open-circuited, the car cannot be operated until the sixth or first parallel position is reached. When the open circuit is located in No. 2 motor's circuit, motor No. 1 can be operated when the controlling cylinder is in position midway between the fifth and sixth positions. This also refers to a type K–10, K–11, or K–12 as well.

The motor nearest to the fuse box is termed No. 1 motor, and No. 2 motor is the farthest from the fuse box. In case that you cannot open the controller cover to cut out a motor in the regular way, you can get power on the first position by closing the armature and field circuits. To do this, you will disconnect the motor connections of the defective motor, and take two short pieces of wire and connect (electrically) the two brush wires together, and the two field wires together, and then your car will start on the first position. This, of course, is not

the proper method of cutting out the motor, but it is shown only in case you were unable to open the controller cover and were operating your car on a line with a long headway; besides, controller covers are sometimes difficult to open, and if you did not have a pair of gas pliers or some similar tool it would be impossible for you to open it.

When you have occasion to connect the brush leads and field leads together, as previously explained, you should not apply the power farther than the fourth position on a 7-point controller, and not farther than the fifth position on a K-2, K-10, or K-11 controller.

LAMPS

In case of a burnt-out globe, you can light up your car by placing a copper cent in the lamp socket and then putting the lamp back again, or by breaking the globe and twisting the wires together you can obtain the same results.

You should not experiment with this, however, unless you are positive that the carbon in the lamp is either broken or burnt off, because incandescent lamps are expensive.

By holding the globe between you and the light, you can easily see if the carbon or filament is broken, or at night, when a lamp burns out, the conductor can sometimes see the defective lamp arc as the carbon is burning off, and sometimes after it is entirely burnt off it will arc when the two ends of the filament touch each other, as the vibration of the car will do this or by jarring it.

The better way to do would be to use the one-cent piece, because you can do it much quicker and it is more simply done; besides, the burnt-out lamp with the globe broken is not worth

as much as the one that is not broken. Railroad companies get a rebate on lamps when returning burnt-out lamps where the globe is not broken. When you break a globe, you have to first turn off the lamp-circuit switch. At times you may turn it too far, and instead of turning it off it is again thrown on, and when you put in a short-circuited lamp you will receive a shock.

In case of failure to throw off the power on any style of controller, do not forget that by throwing off the overhead switch cuts out all connections with the motor.

When a car jumps the track and the track is in proper condition, you should not fail to report the matter to the proper person, so that the car may be run in the inspection shop and examined for sprung axles, broken flanges, or loose wheels, etc.

When an axle is sprung, you will easily notice it while riding on the car by the see-saw motion it makes. In this case you should be cautious in going over crossings, taking switches, and in passing around curves, as the car is liable to become derailed.

When an axle is sprung so badly that the wheels will not stay on the track, the car should be moved ahead or back, until you find a place in the wheels that fits the track, then make one of the wheels fast to the truck frame and tow or push it to the car house. If you cannot get a rope or a chain, use a draw bar to secure the wheel.

If it is a double-motor car, cut out the motor that has the wheels locked, and use the other motor to help the car along.

If you have a car that has a broken wheel flange, you should operate very slowly and cautiously over curves and track that has bad joints, even if it is a straight track, and the greater

the piece broken out of the wheel flange, the more cautious you should be.

If it should occur that you cannot get around a curve without derailing the car, you should back up the car until you get a place in the wheel that is not broken, and then either tie it with rope or chain, or place a draw bar so as to lock the wheels and then push the car around. When you can get a rope or chain, it is much preferable to lock the wheels with it than to use a draw bar, as the draw bar is liable to become wedged in the truck frame and become difficult to remove.

If the car is a single-motor car and is standing on a curve, it would be advisable to pull it back off of the curve, and then when you are moving ahead keep moving until you get around the curve. I state this on the supposition that the motor should be on the forward end in that direction, and if it is and you try to push it out of a curve, you would be liable to throw the rear end off the track.

Broken flanges are generally caused by striking curves too hard, going over railroad crossings too fast, or running over obstacles on the track such as horseshoes, spikes, and pieces of iron. When the tread of the wheel is badly worn, generally the flange on one wheel is worn much thinner than the other, and in striking a curve hard it is very liable to break off, as also in going over a crossing too fast with the car running on the flanges and not on the tread. This generally occurs where new special work has been lately put in on the track.

With a broken axle, nothing can be done by the motorman but telephone to the proper place for the wrecking crew, and also telling the crew on the first car going in the opposite direction, so that if it is possible they can notify the inspectors of

the trouble, who in turn will look out for the operation of the line in reference to maintaining headways.

With a broken gear, the only thing that you can do is to lock the wheels and get the car to the car house; or, if it happens somewhere near the end of the line, so that the car can cross over and get on the other track, you should call for the wrecking crew. In case of any unusual noise with your car, you should report it at once, so that it can be examined and the trouble located.

In case of a double-truck car getting off the track, and you try to get it replaced, you will find it advantageous to work from the motor end, because if you work from the light end and move the car with the light end in front, the truck is liable to swing further away from the track. If it is off in a switch in such a way that the light wheels will not climb the rail, by backing up it will drop on the rails at the frog or switch.

When a car has a charged platform, you will generally find it on the No. 1 motor end of the car. When taking on passengers you should be sure that they are safely on the car before you apply the power, or they might receive a shock. Of course you should receive assistance from the conductor in this respect.

When slowing down at a crossing to let persons board your car, do not apply power until they are safely on the car. When a platform is charged and you apply the power just as a person is taking hold of grab handle, he would receive a shock which might result seriously and also would be a case of liability against the company.

In case you find smoke coming out of a motor you should cut out that motor at once, or it might result in serious damage

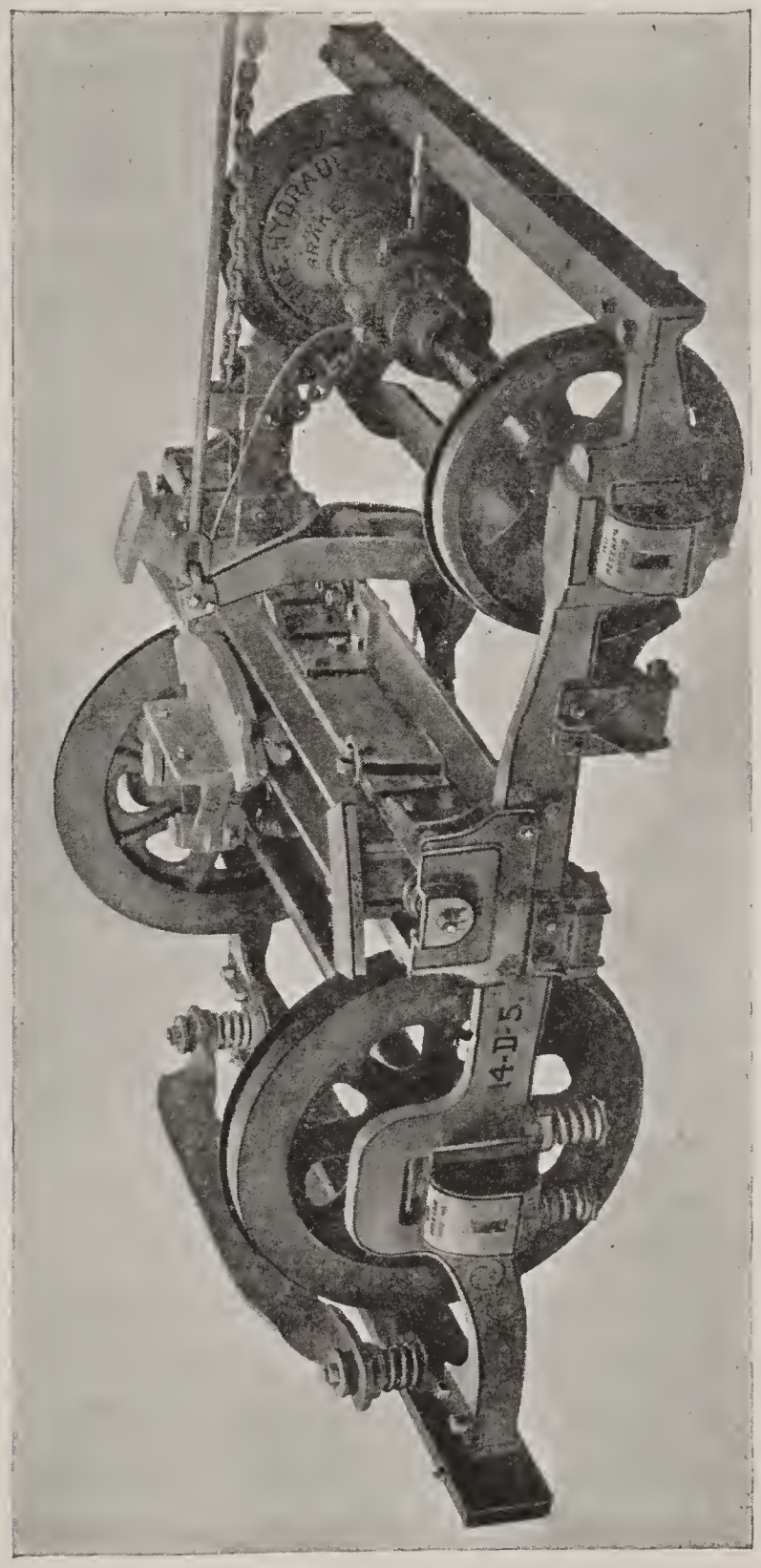


FIG 21.—Peckham Swivel Truck Type 14, D. S.

to the armature or field. When you have a controller with a grounded cylinder and you want to operate your car from that end, you can proceed as follows: Throw off the overhead switch on the end that you wish to operate from, then at the other end of car reverse for the backward motion and, placing controller in the first safe position, take off the controlling handle and operate the car from the front end with the overhead switch.

When cars are equipped with electric headlights, motormen should be sure to report when they find any headlight glass broken, so that glass may be replaced and the circuit protected from water or snow.

A car with a grounded lightning arrester will blow a fuse when the car is at rest with both overhead switches on. The lightning arrester is placed underneath the car body and at the No. 1 end on single-truck cars. You will find that there are two wires connected to one end, and one wire to the other end; also a small wire which is the light circuit ground wire. To be able to operate your car and prevent the blowing of fuses, you should disconnect the two wires from the lightning arrester and connect them together and operate your car in the usual manner, or else remove the main ground wire. This refers to a T. H lightning arrester.

A motorman who takes an interest in his work will familiarize himself with the different parts of the car body and truck, so as to be able to report on the condition of the car in an intelligent manner when laying up a car in the car house.

TROLLEY

A complete trolley consists of a base, stand, and trolley pole, to which is attached a trolley wheel. This entire forms a circuit from trolley wire to car circuit. The wiring of car circuit begins with the wire connecting with trolley base.

BASE

The base is of cast iron, and is secured by bolts to roof-board of car (also called trolley base-board). The base supports the spindle, which carries the trolley stand. The stand is equipped with springs for giving pressure against trolley lines with trolley wheel. The stand also has a socket which receives and secures the trolley pole or trolley pressure bar. The pole or pressure bar is made of steel tubing, which is formed by graduating dies, which give the proper shape and dimension. The length of trolley pole or bars varies from 13 to 15 feet. The diameter is $2\frac{1}{2}$ inches, and $\frac{7}{8}$ inches at the ends, respectively. At the smaller end of pole is attached the trolley head or fork, which supports the trolley or under-running wheel. The wheel has a graphite bearing, which dispenses with the necessity of oiling same.

The proper handling of the trolley pole falls to a great deal on the motorman. A car should always be run slowly and cautiously around curves and over crossings, and the power should always be shut off completely in going over circuit-breakers.

When the conductor is collecting fares, which he should do where there is a straight track, you should run your car so as to make a stop as quickly as possible in case the trolley pole

leaves the wire. If you pay strict attention to the handling of a car, you cannot fail to notice the slight check in the speed of the car when the trolley leaves the wire.

Where there are cross-overs and switches, you should exercise great care, because if the trolley fork becomes entangled in the frog, it will either pull off the trolley stand, or possibly pull the trolley wire down, thereby causing a serious delay on the line. Besides there is the possibility of a trolley stand dropping or the trolley wire falling upon some person.

When a trolley wire is pulled down, you should not leave it without some one in charge, as some driver might drive his horses against it. If there is not much of the wire down, you might be able to clear it to one side, so that the cars could clear, and in that case a good plan would be to wait until your follower came, and then you could continue on your trip and your follower could work it in the same way that you did, until the emergency crew could arrive and take charge of the fallen wire. The first thing, however, that should be done would be to telephone to your depot informing them of the trouble and the exact location. If the wire should fall on the rail, you should try and clear it away, and you could do this in safety by taking hold of the wire with your cap or coat, or by means of a dry stick of wood. This would relieve the power station from the *ground*, besides keeping the cars in operation, and if you could find some pieces of wood around, you could lay the wire down on them and thus prevent a ground occurring again. There has never been a trolley made which will prevent the trolley wheel from leaving the wire if a car is run in a reckless manner around curves and over crossings and circuit-breakers.

You should always bear in mind that a trolley is intended

to follow the car and not intended to go ahead of same, and you are never safe when backing your car without first turning the trolley pole. When a pole has been bent by backing up without turning it, the superintendent can easily see how it was done.

When a trolley wheel is lost out of the fork, a good plan is to place a piece of wire in the axle holes; this has a tendency to keep the fork a little farther away from the wire than if you ran it without; the nearer the fork is to the wire the more liable it is to become caught in a frog or diagonal, or at an anchor ear in the line.

CONTROLLER TROUBLES

Controller troubles are probably the most frequent of any experienced with street railway cars. This is especially so with the older types of controllers. A great deal of this trouble is caused by careless handling, and in failing to move the power handle a full notch at a time, consequently causing arcing at fingers and contacts, until finally there is no contact at all or the finger and contact are blistered. A finger may get caught so that you cannot get beyond a certain position, or it may be that you will get no power on some of the positions, or perhaps the car will not move at all from one controller.

An inspection of the controller will probably show that one of the fingers has no contact, and a new finger will have to be provided. Or in consequence of the continual arcing between the finger and contact, there is a possibility of the temper being taken out of the tension spring of a finger.

It does not always follow that the man that has trouble with a controller is the one at fault; it may be that the motorman

that had it previously caused the trouble; but when a motorman is continually having trouble with his car, it is generally safe to say that he is either careless or possibly ignorant of the workings of a controller and does not follow the instructions as given him when he was first given charge of a car. A great saving for the company can be made by the careful operation of a controller. It is often noticed that the motorman applies the power so rapidly as to cause the wheels to spin around so quickly that they have no chance to adhere to the rail. When a dry piece of rail is reached, the wheels suddenly grip and then the car would leap forward with a sudden movement. In damp weather, if the rail is somewhat slippery, they will throw the power all the way on, and, if they have sand, they will drop it without using good judgment; the car starts forward with a jerk which is liable to damage the motors, or particularly the gears and pinions, and make it very unpleasant for the passengers. If you notice a locomotive engineer in starting up with a heavy load, or on a heavy grade, or a slippery rail, you will see that he opens the valve just a little at a time, but if the wheels should commence to slip he will shut off the steam and commence to apply it again very gradually, and if he uses sand he drops a little at a time, but he does not open the valve to its fullest extent and then drop sand, because if he did something would be liable to give way.

When you apply the power on the first position and the wheel slips, it stands to reason that the more power you apply the more the wheels will continue to slip. If you apply the power gradually and give time for the wheels to grip the rail before moving the power from one notch to another, you will find that you will make time in doing so.

On arriving at a crossing, or any part of a track which is covered with sand, dirt, or water, you should let you car run over same without using power if possible.

There are a great many places on some lines where there are grades, so that a car can be run quite some distance without using power at all, excepting to start the car.

It is to the company's interest that you use as little power as possible in the operation of your car, and what is of interest to your employer is of interest to yourself. In throwing off the power, throw it off lively but not with too much force, because you may break the rivet which secures the cam wheel to the controlling spindle; or, if it is keyed on, it is liable to become loose.

You should never leave a car without first throwing off the overhead switch or circuit-breaker, and taking off controller handles, as it is possible for a car to start up without the power being applied with the handles during rainy weather. This is something that very rarely occurs, but it is actually possible for such a thing to happen.

HAND BRAKES

The hand brake is the oldest type of brake which was used for governing and stopping cars. It is operated by hand, using either the crank or wheel for manipulation. The crank handle is the one generally used by street-car systems. The brake leverages of the truck mechanism of brakes is such as to conform to the weight and varied conditions of car.

DEFECTS

The failure of the brakes is a very serious matter, especially if the brake chain or rod parts, or if it becomes detached from the brake lever through the bolt's either breaking or dropping out. (The bolt referred to is the bolt that fastens the brake rod to the brake lever.)

If this should happen on a crowded thoroughfare you should immediately reverse your car and apply the power, just a little, bringing the car to as near a standstill as you can, and then signal your conductor to put the rear brake on. When the car is entirely stopped, you can arrange with your conductor as to what shall be done.

In an emergency of this kind it would be well to do everything without letting the passengers know that anything out of the ordinary had occurred. The safest way would be to have your car pushed or towed to car house, and it is always safer to have the car towed than it is to have it pushed (as then the car being operated would be in front, which is much the safer way). This rules applies to all cases when cars are disabled and cannot be operated.

If the cars are on a long headway, and the streets are not too crowded, you could, by a prearranged signal, run your car home by the conductor operating the rear brake. Of course the motorman, in such a case, must stand ready to use the reverse and must greatly increase the distance in which to make a stop.

When it becomes necessary to use the reverse, do not put on the power too fast. On a controller car the first or second, or not more than the third, position would do, and on a car

equipped with a T. H. rheostat the first quarter would be sufficient.

All the power that it is necessary to apply is just sufficient to turn the wheels slowly in a reverse direction to that in which the car is moving. Make sure and reverse fully and follow the instructions given in regard to putting on the power, because if you put on too much power at once it is liable to blow the fuse, and then you surely would be in a sad plight. The only thing for you to do in case you reverse the car and the fuse blows out on account of a brake failure of any description would be to throw the controller handle all the way around to the "loop" or last parallel position. In case of a broken brake chain it would only take a short while to take the brake chain from the other end and use in place of the broken one. If you ever have occasion to do this, first block the wheels so that the car would not move, and with the aid of a small monkey wrench you could make the change in a short time.

In case of a brake rod-bolt breaking or dropping out, you could use your bell-pin if it was short enough and did not catch on the pilot board when the brake was released; this, of course, would depend on the style of the truck under your car. It might happen that the brake chains are getting longer each trip you make and winding around the brake spindle two or three turns, which would result in your failing to stop a car in the distance that you ought to, or perhaps not at all. You will possibly find that the turn-buckles have slacked off on the brake-connecting rod, and you can easily determine this by seeing whether the turn-buckle has turned away from the check-nuts or not, and if they have, you could turn the turn-buckles back up to the check-nuts and operate your car in safety. When

anything like this occurs you should report the matter as soon as possible. Of course, these are things that should very rarely occur, but it is well to know how to temporarily repair them, so as to complete your trip or day's work or continue until you get to the depot.

In operating a car you should always know where the brake handle will set to stop a car, and to know this you should set the handle by ratchet until you get it where it will suit you best and then let it stay there, and not let it fly off in releasing the brakes. If you do you cannot know where the handle will set when you come to make your next stop. Besides this being an important point in the handling of your car, it is very disagreeable to passengers to have a motorman continually letting fly the brake handle and making a disagreeable noise. This is especially noticeable on open cars when passengers are riding on the front seat.

You should not have your brake set any when you have the power on, and in going down grade you should allow the car to coast as far as possible without using power, keeping the car under control all the while, and not running in excess of speed allowed and determined by your superintendent.

You should strive to become a good judge of distance, so that you could be able to tell nearly how far the car will run after shutting off power.

You also must take into consideration the grade at a point where you wish to stop a car. In no event whatever allow yourself to run a car at high rate of speed toward a crossing, or endeavor to make a stop suddenly.

When the rail is in a slippery condition, or during a heavy fog, you should run your car very cautiously.

A brake that has such good leverage and is so evenly adjusted as to slide all the wheels without unusual exertion on the part of a motorman is certainly a good one, and neither steam, electric or air brakes can do any more than this; but a competent motorman will, when he feels the wheels sliding, release on the brake, then reapply the brakes to make his stop.

In regard to the use of sand: some motormen will not use one sand-box full during the entire day, while another man will fill both boxes on each trip. The one man uses it only when absolutely necessary; just a little in starting up on a slippery rail and sometimes a little in stopping, in case a team cuts in on the track ahead of him, but for all stops to take on or discharge passengers, he does not use sand at all. The other man uses sand without any judgment, as though the more sand he used the better motorman he was. In starting up, the car does not move fast enough for him, because instead of applying the power gradually he throws the controller perhaps on the last position and the wheels spin around, but the car makes but little headway; he then pulls the sand lever and drops a lot of sand and away goes the car with a bound and a noise as though it was running over cobble stones. Before he recovers himself from the sudden start the car gives, he is close to the next street crossing, and if he gets a bell to stop, then down goes the brake again with all his might, the wheels slide on the slippery rail, and then he jumps for the sand lever again and drops more sand, by which the car comes to a sudden stop. When he starts again the car has a flat wheel. He has done so much damage in five seconds that it will necessitate the taking out of the wheels and putting in another pair while the first ones are having the flat spots ground out of them. This operation takes

from two to five hours. Besides, there is the enormous expense of new wheels and the loss while the car is out of service.

Motormen should strive to be able to tell the difference between bad rails and a bad brake, and when either of these two conditions exist, all precautions should be taken against collisions of any description.

OPEN CIRCUITS

An open circuit means that the circuit is either broken or parted at some point. When an open circuit occurs on trolley wire circuit of car between trolley stand and main motor switch, car cannot be operated by either controller on any position.

When an open circuit occurs, either in the wire leading to the fuse box, or wire leading to and connecting with the lightning arrester, or wire leading to and connecting with wire in cable marked T, the car cannot be moved in either direction on any position with controller.

When the open circuit occurs with the R–1 wire, or in panels of resistance of this connection, the motors cannot be operated on the first position of the controller, but may on the second position. To overcome this defect, connect R–1 and R–2 contact wipers in controller together with wire. This will allow the motors to be operated on the first position, but the motors will acquire the same speed as they would on the second position, if there had been no open circuit at all. See Diagram No. 22.

When an open circuit occurs on the R–2 wire, the motors can be operated on all series positions, but cannot be operated on the first parallel position of controller. When the open circuit is located in the panels of resistance, the motors

cannot be operated until the third position is attained on the controller. Also, the motors cannot be operated on the first

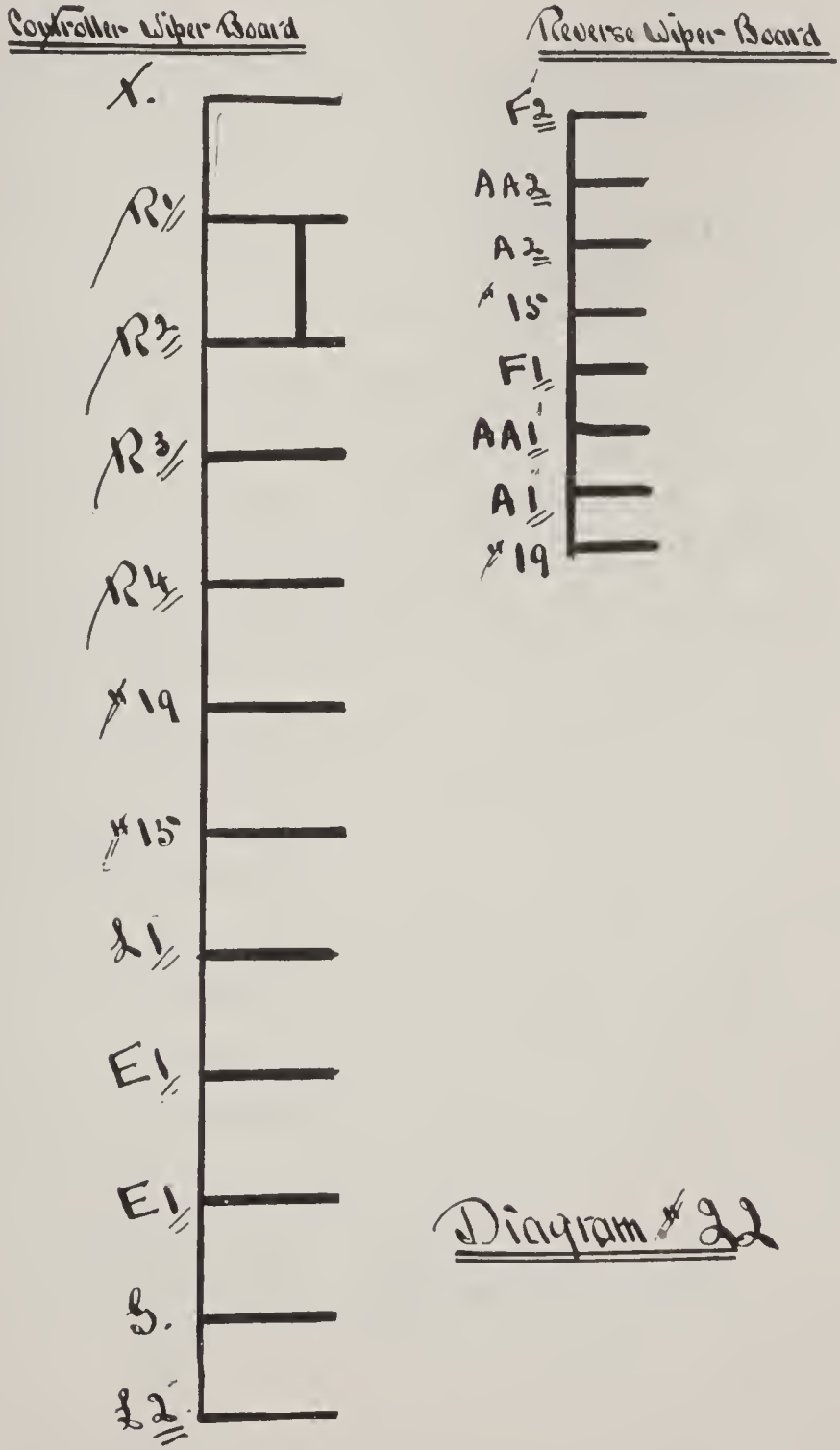


FIG. 22

parallel position. To overcome this defect, connect the R–2 and the R–3 contact wipers in controller together with a piece of wire. This will allow the motors to be operated on all positions with the controller, the motors acquiring the same speed on the second position as that of the third. The object of forming this connection is so that the motors may be operated on each and every position with controller. For making this connection, see Diagram No. 23.

When an open circuit occurs on the R–3 wire and the defect is located between the contact wiper in controller and tap on resistance jumper wire, the motors can be operated on all positions with the controller. When an open circuit occurs on jumper wire between the first rheostat and R–3 tap lead, the motors cannot be operated until the third position is attained, also, on the seventh as well, the sixth position being cut out.

To overcome the last-named defect, connect the R–2 and R–3 contact wipers in controller together with a piece of wire, the same as in Diagram No. 23. When the open circuit occurs in the panels of resistance of the R–3 connection, the motors cannot be operated until the fourth position is attained; also, cannot be operated until the eighth position is attained as well on the controller. To overcome this defect, connect R–3 and R–4 contact wipers in controller together with a piece of wire; this will allow the motors to be operated on all positions with controller, the motors acquiring the same speed on the third position as on that of the fourth. This applies to the G. E. controllers, types K–2, K–10, and K–11. To form this connection see Diagram No. 24.

When an open circuit occurs on the R–4 wire of type K–2 controller, the motors cannot be operated except on the fourth,

fifth, eighth, and ninth positions, respectively. To overcome this defect, connect R–3 and R–4 contact wipers in controller

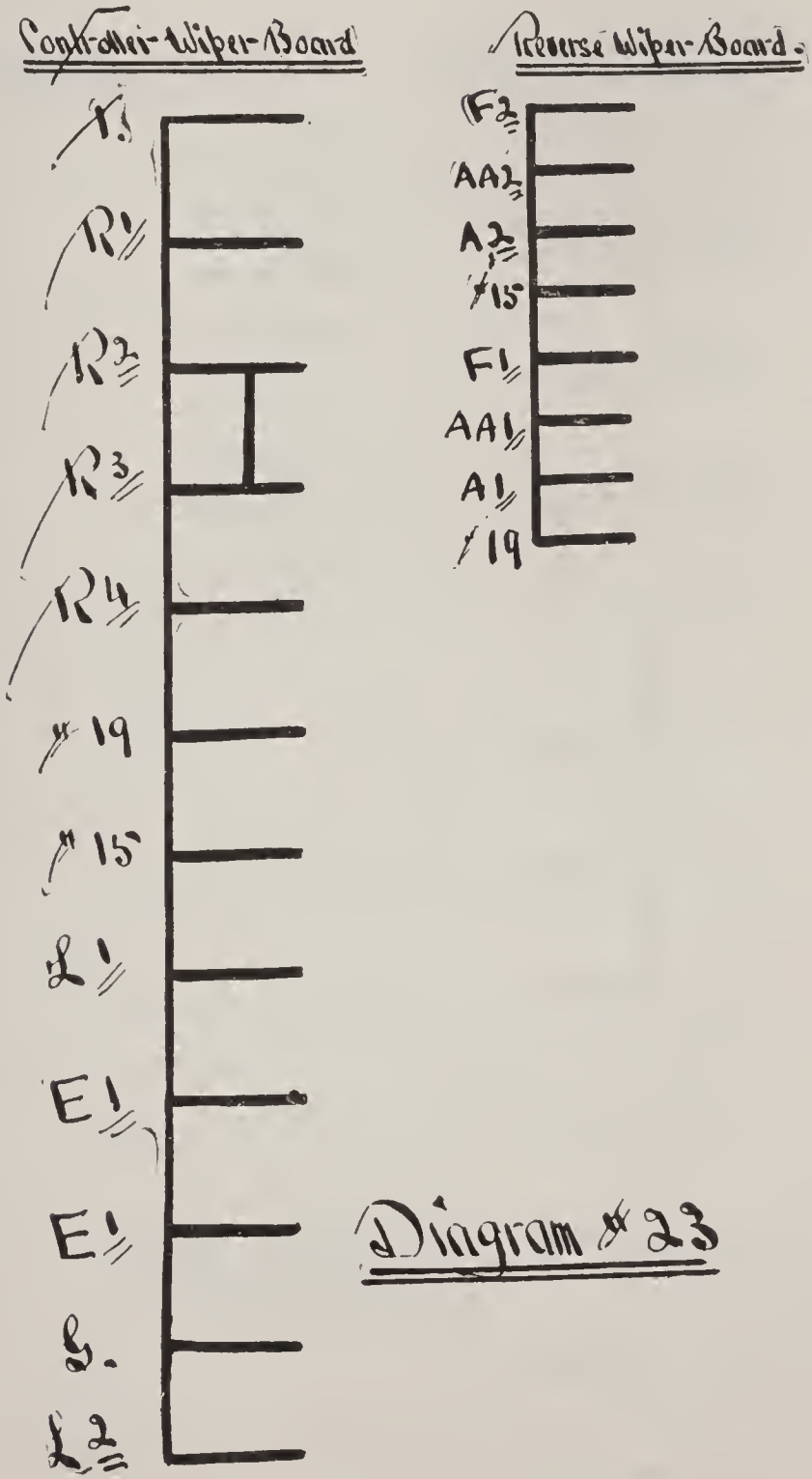


FIG. 23.

together with a piece of wire; this will allow the motors to be operated on all positions with controller, motors acquiring the

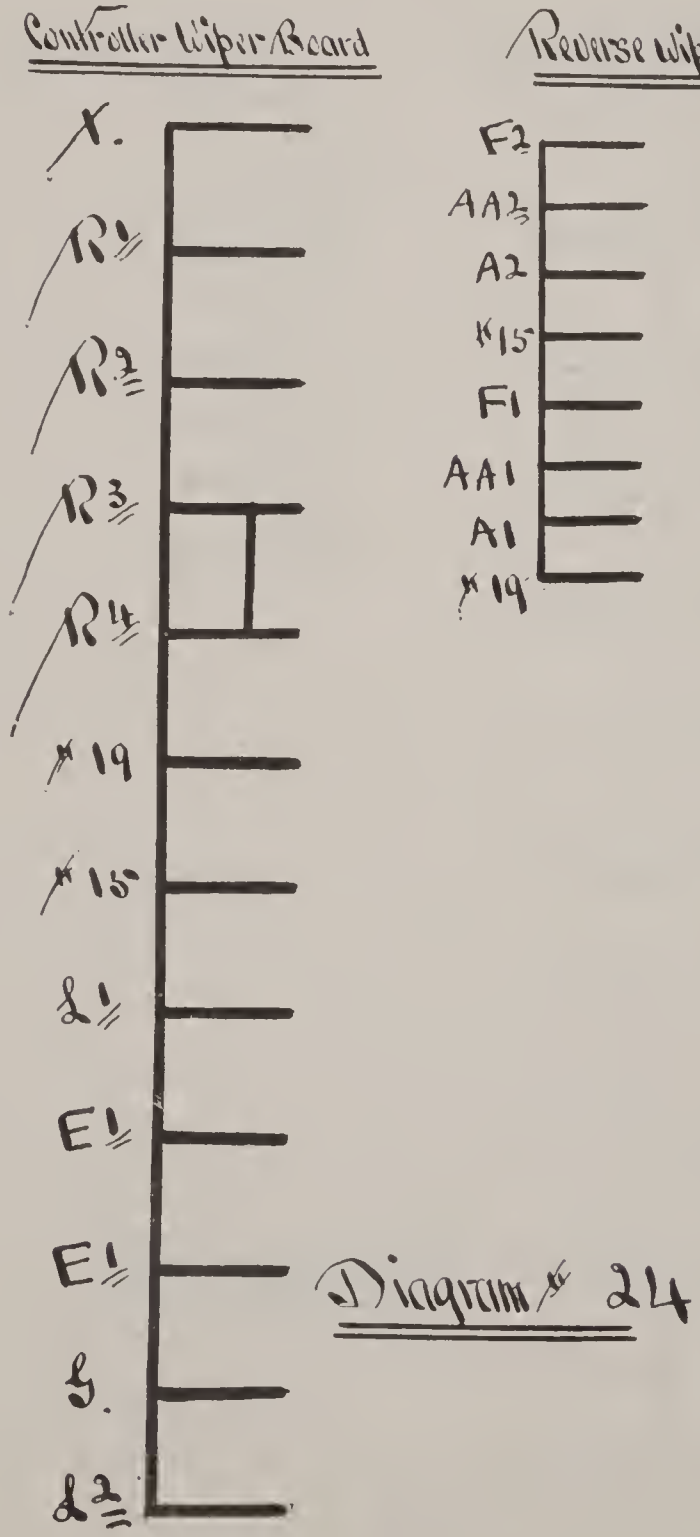


Fig 24.

same speed on the third position as on that of the fourth. This applies to the G. E. controllers, types K–2, K–10, and K–11. To form this connection see Diagram No. 24.

When an open circuit occurs on the R–4 wire of type K–10 or K–11 controller, the motors can be operated on all positions with controller; but if open circuit occurs in panels of resistance the motors can be operated only on the fifth and ninth positions respectively. To overcome this defect, connect R–4 and R–5 wipers together in controller with a wire; this will allow the motor to be operated on all positions with the controller; the motors acquiring the same speed on the fourth position as that of the fifth. This applies to the G. E. controller type K–10, and K–11. To form this connection see Diagram No. 25.

When an open circuit occurs on the R–5 wire of a type K–10 or K–11 controller, the motors can be operated on the fifth and ninth positions only. To overcome this defect connect contact wipers R–4 and R–5 together as in Diagram No. 25. This connection closes the circuit with rheostat or resistance and allows the motors to be operated on all positions with controller, the motors acquiring the same speed on the fourth position as that of the fifth.

When an open circuit occurs on the field lead of motor and arc in connection with a G. E. type K–1 and K–2 controller, with shunt method in connection, the motors cannot be operated until the fourth position on a K or K–1 controller is attained, or until the fifth position is attained on the type K–2 controller. To locate the defective motor, first cut out the No. 1 motor and try to operate the car on the first position with controller, but if circuit cannot be formed, cut in the No. 1 motor and try by cutting out the No. 2 motor.

When an open circuit occurs on an armature lead or reverse switch connection the motors cannot be operated on any of the

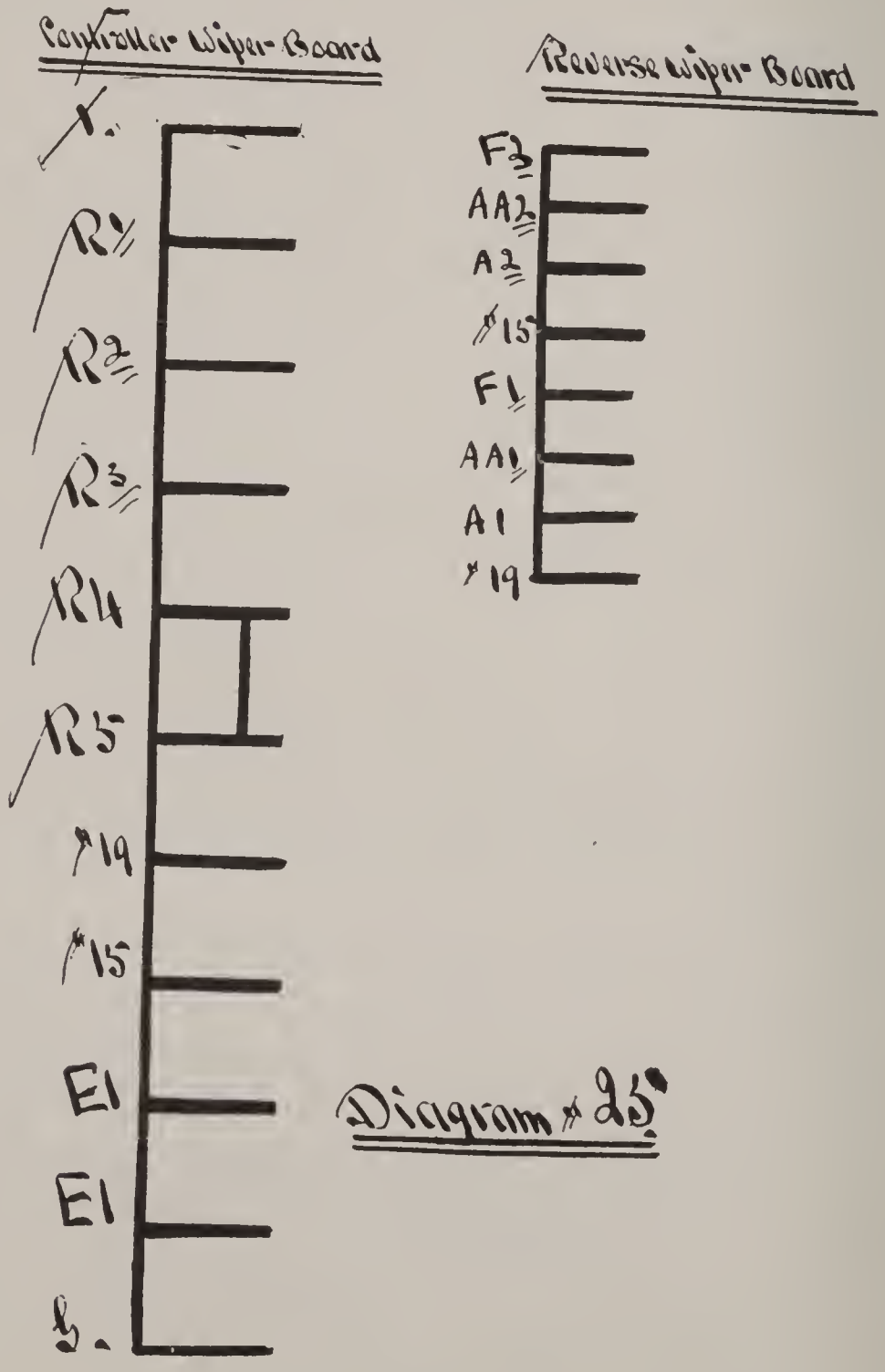


FIG. 25.

series positions, but motor in circuit can be operated on any of the parallel positions.

When an open circuit is located on No 1 motor's armature lead or reverse switch connection, the No. 2 motor cannot be operated until the first parallel position of the controller is attained. When an open circuit is located on No. 2 motor's armature lead or reverse switch connections, the No. 1 motor cannot be operated until the arrow indicator of the controlling cylinder handle is midway between the series and parallel position.

DEFECTS IN MOTORS

Under this heading a brief description of the various troubles and causes in street railway motors will be explained.

First. GROUNDED ARMATURE. — A grounded armature is the result of one or more of the armature coils becoming in metallic connection with armature core or pole piece. This defect causes fuse in circuit to be blown. When the defect is located in No. 1 motor's armature circuit the fuse will be blown on the series positions, and when located in No. 2 motor's armature circuit the fuse will be blown on the parallel positions with controller, providing both motors are held in circuit by their respective cut-out switches. With this defect no repairs can be made, except at armature repair room.

Second. GROUNDED COMMUTATOR. — A grounded commutator is the result of a segment or segments of the same becoming in metallic connection with the frame which supports it. This defect causes fuse to be blown in circuit, the same as that of grounded armature coil. This defect is either caused by an accumulation of carbon dust, or grease from the outer

edge of commutator and extending to shaft of armature, which allows a short circuit to take place and causes fuse to be blown in circuit. With this defect, no repairs can be made except in armature repair room.

Third. Open-circuited Commutator. — An open-circuited commutator is caused by an armature coil lead parting or burning off near binding terminal of commutator. The defect is noticeable by a sharp flash on commutator, when the

Fig. 26.

positive brush passes this bar, also the mica insulation between commutator bars will be more or less burned by the arcing of brush. This presenting itself next to bar having the open circuit.

Fourth. Grounded Field. — A grounded field is the result of the coil of wire composing same to become in metallic connection with motor frame at some point or other. This defect causes the fuse in the circuit to be blown, providing that the longest portion of the field circuit is cut out by this ground.

When the defect is located in No. 1 motor's field circuit the fuse will be blown on the series positions, and when located in No. 2 motor's field circuit the fuse will be blown on the parallel positions of controller, providing both motors are held in circuit by their respective cut-out switches.

The ground of a field usually presents itself at the back of field coil as secured in motor frame, or on the inner side of field coil, next to motor pole piece. No repairs can be made with this defect, except at field repair room.

Fifth. Weak Field. — A weak field is caused by the insulation becoming carbonized, which allows a partial short circuit to be effected upon its own circuit. This defect causes fuse to be blown when using the last running position of a controlling device and can be located in either No. 1 or No. 2 motor. It is also noticeable by the retarded movement of car when current is first applied and on first position of controller, but afterwards by a sudden speed being reached by the motors.

Sixth. Grounded Brush-Holder. — A grounded brush-holder is the result of the metallic frame composing the same becoming in connection with motor frames either by some metallic connection or by carbonization of brush-holder yoke. This defect causes fuse in circuit to be blown as follows: When the metallic frame is in metallic connection with motor frame and located in No. 1 motor the car cannot be operated in either direction, causing fuse to be blown on series positions with controller. When located in No. 2 motor the car can be moved on a series position, the fuse being blown on the parallel positions of the controller.

When the grounded brush-holder is caused by carbonization the fuse will be blown when using the last position of con-

troller and can be located in either No. 1 or No. 2 motor. To determine which motor carries this defect, first cut out No. 1 motor, testing the circuit of No. 2 motor on series position with controller. If no fuse is blown with this test, the ground will be located in No. 1 motor as cut out, but if fuse is blown, cut in the No. 1 motor and cut out No. 2, which will allow a test to be made with No. 1 motor's circuit.

When the wires F–1 and F–2 at the shunt connection become short-circuited with each other, and both motors are cut in with their respective switches, a car cannot be moved in either direction.

MAIN MOTOR SWITCH

A main motor switch is an electrical device placed in circuit of trolley wire, in car wiring, for the purpose of opening or

FIG. 27.—W. H., M. M. Switches.

closing that circuit at either end of car. Several other names are given to it, namely *overhead switch*, *canopy switch*, and

sometimes *auxiliary switch.* The switches are constructed with a blow-out magnet coil placed in circuit with switch lever for the purpose of breaking an arc when opening the circuit. The magnet coils are inserted in interior of switch.

FUSE BOXES

A fuse box in an electrical device placed in the trolley circuit of car wiring for the purpose of opening a circuit (by the blowing of fuse) when an overload of current is applied, thereby protecting the electrical equipment of car. This device is usually constructed in the form of a box, in which are inserted two binding-posts, representing positive and negative poles of the device. To these are attached two wires, — one the trolley wire, which is attached to the positive binding-post of the fuse box, and the other wire, attached to the negative binding-post, is the wire leading to and connecting with through lightning arrester to trolley contact wiper in controller. The fuse box is usually equipped with a blow-out magnet coil (which is in connection with the positive binding-post of device), the office of which is to extinguish the arc when fuse is blown.

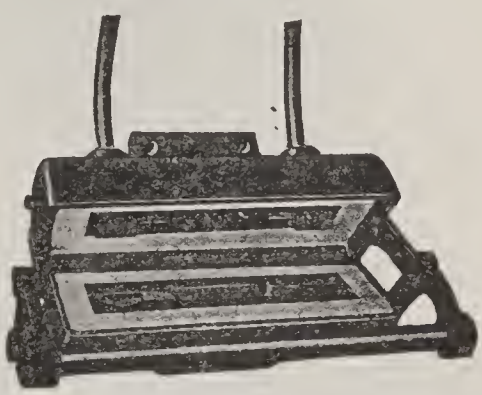


FIG. 28. — Fuse Block for Railway Equipments. Single Pole. Style No. 3794. Open.

LIGHTNING ARRESTER

The lightning arrester is a device placed on the trolley wire circuit of car, between the fuse box and the controller connections. It is for the purpose of grounding an excessive charge

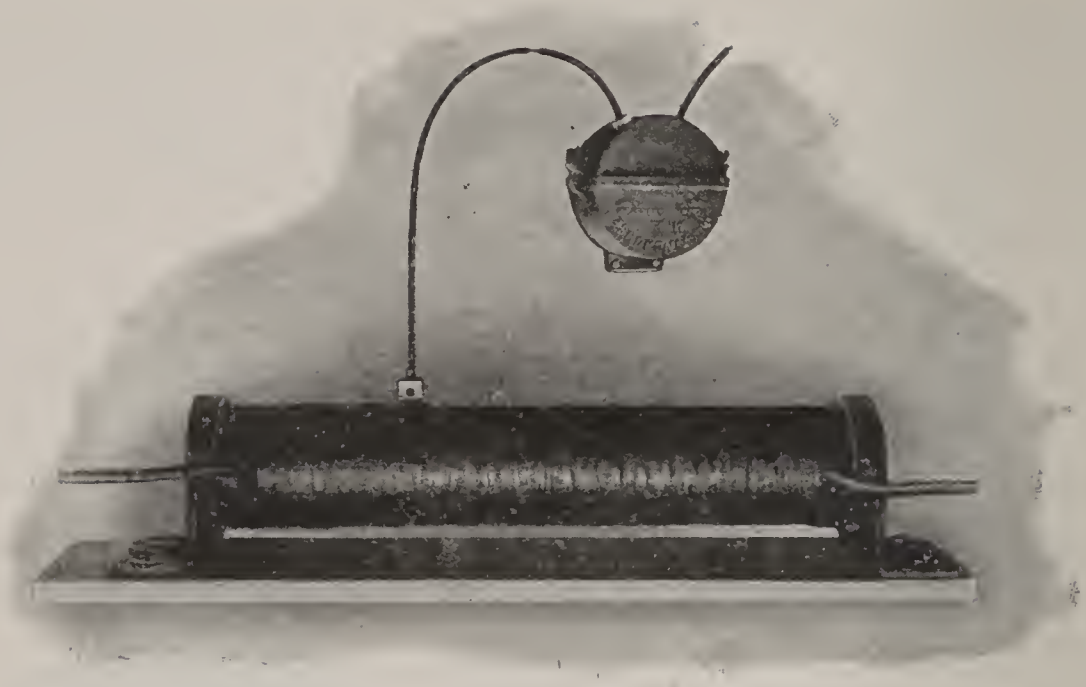


FIG 29.

which might occur on the line, resulting from lightning. This device is usually placed in the trolley circuit, between the fuse box and trolley contact wiper in controller or rheostat spindle in T. H. system.

FIG. 30.—Type MP Lightning Arrester for Railway Service.

The more modern types of lightning arresters are connected directly across the entire circuit. That is, a wire is attached to trolley wire of car, and connects with the pole of arrester. A second wire is connected from the negative side of arrester to main ground wire. An open circuit exists between the positive and negative side of lightning arrester circuit.

When a short circuit occurs, there are no repairs which can be made, except to cut out the arrester; this is accomplished by disconnecting the wire on the positive side of circuit.

When an open circuit presents itself in a lightning arrester of the more modern types, it will not be noticeable to the person operating the car.

The office of the lightning arrester is to protect the car equipment from excessive currents, caused by lightning discharges.

THE CAR MAGNETIC CIRCUIT-BREAKER

A magnetic circuit-breaker is an electrical device which works automatically on its own circuit when a certain amount of current is reached. It is constructed for the specific purpose of opening the circuit when an overload of current occurs, thereby protecting the electrical equipment of a car. When a car is equipped with this device it obviates the use of a fuse box in the particular circuit in which it is. The circuit-breaker is only in circuit with controller on one end of the car, a separate

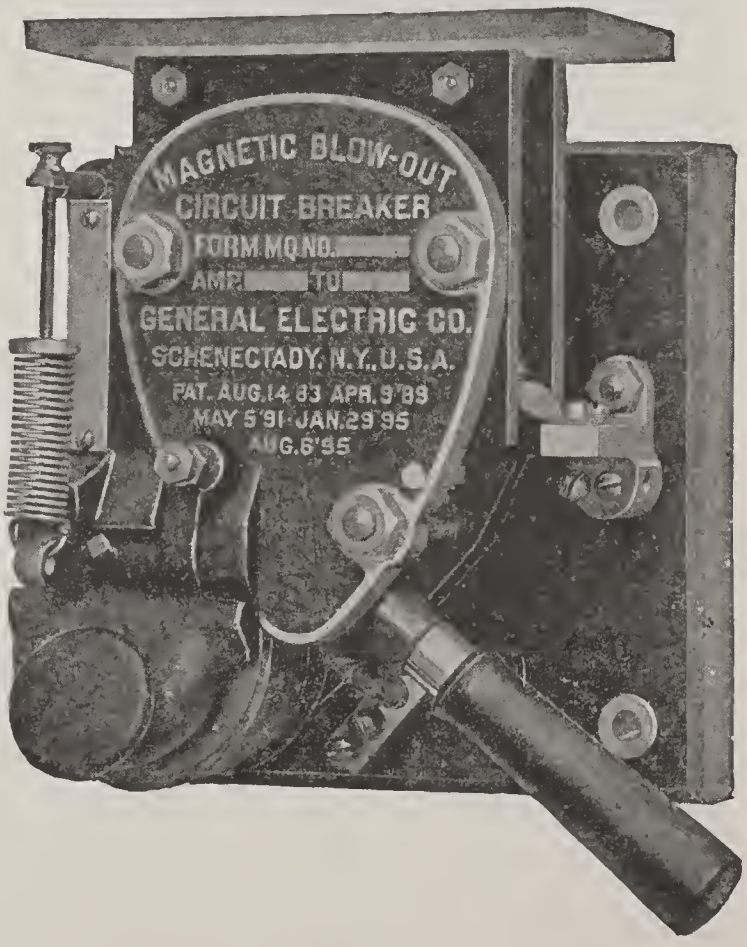


FIG. 31. — G. E. Circuit-breaker.

one being placed at the other end. When operating car at the opposite end the circuit-breaker last used should be tripped to open the circuit. The circuit-breaker usually consists of two binding-posts, to which are attached the positive and negative wires, and in the circuit is placed a blow-out magnet coil, the function of which is to attract what is known as the armature, and releasing the trip which secures the contact lever. The cause of this armature being attracted is the occurrence of an overload of current, which is excessive; this increases the magnetic field so that the armature is attracted by the pole piece of coil, which results in opening the circuit.

FIG. 32.—W. H. Automatic Circuit-breaker for Railway Equipments.

LAMP CIRCUIT

The lamp circuit used in cars is what is known as a series circuit, with usually 5 lamps in the series, and the number of circuits in a car may be one or more, but usually does not exceed three. This refers to a 500-volt circuit, equipped with 110-volt lamps, but when 75-volt lamps are used, 7 constitute a circuit. One of the circuits is in connection with the head-light of car, in which there are 6 lamps, but only 5 are placed

in service by means of a two-way switch. The entire number of circuits are controlled by one main switch.

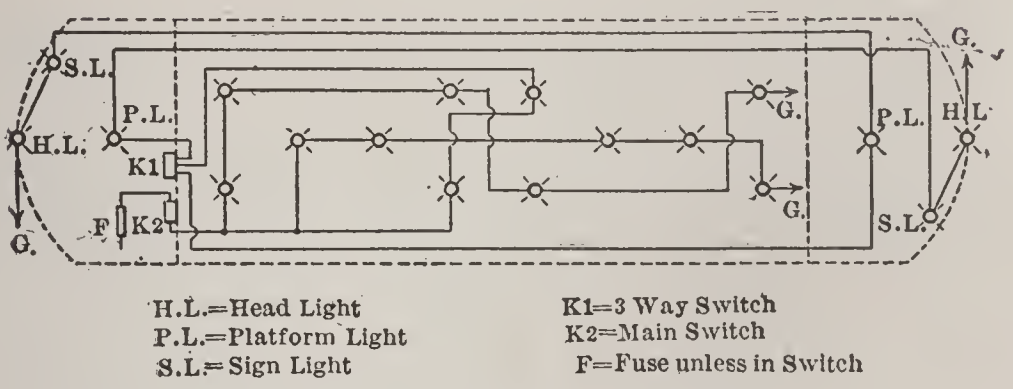


FIG. 33. — Lamp-circuit Diagram.

MAIN LAMP SWITCH

The main switch for lamp circuits is termed a two-pole switch; the contacts are mounted upon a porcelain base, having a porcelain cap. The button for operating the contact lever of switch is vulcanized rubber. The switch is placed in advance of lamps in circuit; this allows the circuit to be opened when making repairs on lamp sockets and cluster circuits. The fuse of circuit is usually placed within the main switch case.

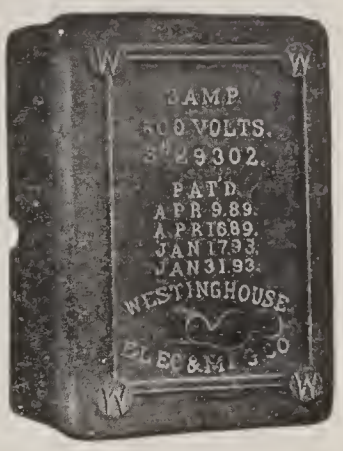


FIG. 34. — Switch for Railway Lighting Circuits. Snap Switch.

TWO-WAY LAMP SWITCHES

A two-way switch is called a four-pole switch; it is placed in circuit usually at the ground end of a three or four lamp circuit, allowing circuit to be completed with the fourth or fifth lamp. They are in circuit with the headlight lamp, which

allows them to be cut out and cut in alternately. There is no fuse in connection with this switch, except the one located in the main switch itself.

OPEN CIRCUITS

An open circuit on lamp switch may be caused in many ways, namely, points of non-contact in circuit wiring, points of non-contact in main lamp switch, points of non-contact in lamp sockets, or by a broken carbon filament in lamp. When this defect presents itself, the lamps in that circuit cannot be burned.

GROUNDED LAMP CIRCUITS

A grounded lamp circuit is caused by wiring or lamp sockets having a metallic circuit with the negative circuit of car. When this defect presents itself, a part of the lamps in circuit are cut out, and where a larger portion of lamp circuits are affected, the carbon filaments in the remaining lamps will burn out, because they carry too much current.

SHORT CIRCUIT

A short circuit refers more particularly to the sockets of lamp clusters; this is caused by the positive and negative side of lamp socket becoming grounded together. This defect cuts out the individual lamp in the socket, upon which the short circuit is located.

A BRIEF DESCRIPTION OF THE CONDUIT STREET RAILWAY SYSTEM

The conduit electric railway system differs somewhat from the overhead trolley system. The conductors of the conduit system are composed of angle-iron bars supported by insulators. One bar is known as the positive bar, while the other is known as the negative bar. These bars are also called contact bars, or channel rails, and are placed about six inches apart and below the surface of the street. The current is conducted to the motors by means of a conduit plow, upon which is mounted the two sliding contact plates, one on each side of the plow; one acting as positive conductor and the other as negative conductor. The rails of this particular system are not bonded or connected, as on the overhead trolley system, as the circuit is completed by the negative return bar. The placing of feeders in connection with the system is similar to that of the overhead trolley system.

MOTORS

With this system, all classes of street railway motors are used; their installation being the same as that of all overhead systems.

CIRCUIT-BREAKERS

There are two circuit-breakers in circuit for a conduit system; one is in circuit with wire T–1, which is trolley, the other with wire T–2, which is the return or negative wire of circuit.

CONDUIT PLOW

A conduit plow is a device having conductors for the car circuit, placed within two sheets of metal and thoroughly insulated from the shank of plow. To the end of these conductors are attached the sliding (F) contact plates, which are mounted on a sliding contact plate spring. At the opposite end of conductors are attached leads having terminals which connect with body terminals of car circuit wiring. The plow is suspended on a yoke secured by two bolts. The extreme end of yoke rests upon two sleeves which slide on two parallel bars called plow bars, which are suspended in truck frame, at right angles to same.

SERIES OF QUESTIONS AND ANSWERS RELATIVE TO THE OPERATION OF CARS OF THE CONDUIT SYSTEM

Q. If a controller was out of order and could not be turned off, how would you open the circuit to stop the car?

A. *Turn off hood or canopy switch.*

Q. What should be done before attempting any repairs?

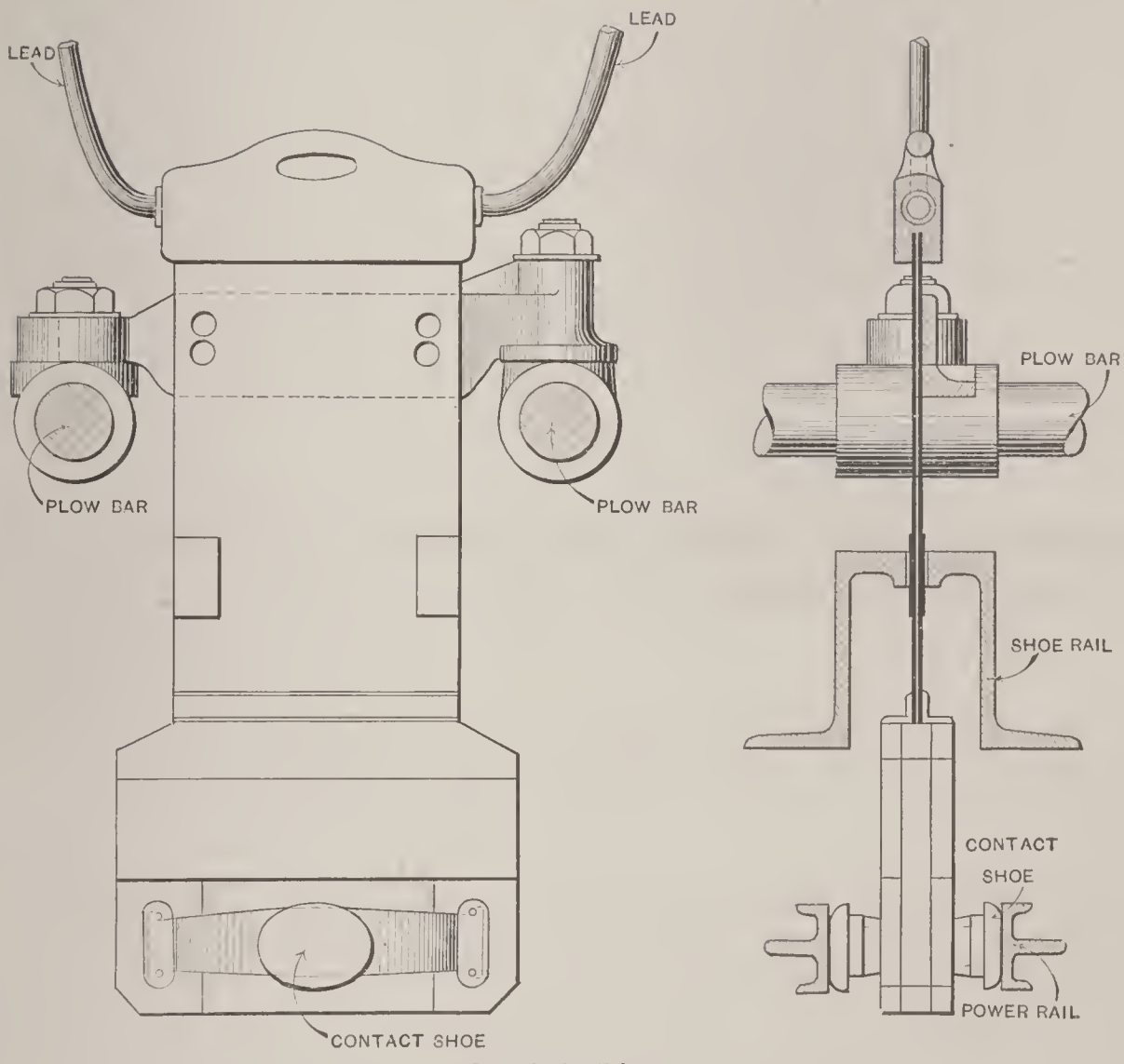
A. *Turn off both ground and automatic switches.*

Q. If lights fail to light, what would you examine?

A. *Automatic or ground switches. If switches are set right examine plow leads. If they should be disconnected and dragging on the ground, connect them at once.*

Q. If automatic switches or fuses blow two or three times in succession, what should be done?

A. *Locate and cut out the defective motor.*



Conduit Plow

Q. If the plow is grounded or commences to burn, what should be done?

A. *The car should be kept moving, but not with its own power if possible to avoid it. A car with the plow in this condition should have the automatic or ground switches turned off and be conveyed to a break in the underground conductor or a plow hatch, where the plow should be removed.*

Q. If a car with a burning or grounded plow is left standing on the rail, what would be the result?

A. *The underground conductor would be burned and destroyed.*

NOTE. — In case a car becomes disabled and it appears that the plow springs or shoes are torn off, the motorman must warn his follower to run carefully over the place where he believes the damage occurred. If two cars lose power in succession, the motorman on the following car must be warned not to proceed until the underground conductors have been examined and put in order.

Q. If any of the circuit-breaking devices on the car were grounded or loose connections commenced to burn, what should be done?

A. *Turn off automatic or ground switches. If the switches were burning and could not be turned off disconnect the plow leads.*

Q. How can you distinguish No. 1 from No. 2 controller?

A. *By a short jumper wire in No. 1 controller connecting cables known as E–2–X and T–2.*

Q. Which end of the double-truck car is the short end?

A. *The end that the plow is on or the end that the register is on.*

POWER OFF AT BREAKS

At points where there is a break in the underground conductor as indicated by marks on the surface of the streets, power must be turned off when the front end of single-truck or short end of double-truck cars reach long mark. Power may be turned on at short marks. If on the long end of a double-truck car, power may be held six feet beyond long mark, and must not be turned on until the front end of car passes six feet beyond short mark. When the power is turned off at the long mark, the circuit is opened in the controller and the blow-out magnet can control and break the arc; but if the power is held on when passing over a break, the circuit is open at the underground conductor, where there is no blow-out magnet to break the arc, and the heat caused by the arc is so intense that the plow fuse is burned, plow springs weakened, and sometimes the plow set afire, which would in most cases ground the section.

* **Q. Name the principal parts of type "K" series parallel controller.**

A. *Controller cap. Controlling cylinder. Water cap and pointer. Star wheel. Check pawl and spring for controlling cylinder. Controlling fingers. Finger board. Contact segments. Safety stop. Interlocking device. Blow-out magnet. Pole piece. Hinge pole piece. Arc deflectors.* Reversing cylinder. *Water cap. Star or index wheel. Check pawl and spring. Reversing fingers. Finger board. Short and long contact segments. Connection board. No.* 1 *and No.* 2 *motor cut-out switches.*

NOTE. — The pointer, star wheel, check pawl, and spring form the controlling index.

Q. Into how many parts is the controlling cylinder divided?

A. *Two parts. The upper part cuts the resistance in and out of the circuit. The lower changes the motors from series to parallel.*

* From N. Y. City Railway Co. Handbook.

Q. Of what use is the blow-out magnet?

A. *To break the arc formed between controlling fingers and contact segments.*

NOTE. — The arc is forced across the magnetic field formed between the pole-pieces of the blow-out magnet and in this way the arc is drawn out, weakened, and disappears in the form of gas. (Blown out.)

Q. What part of the controller forms the poles of the blow-out magnet?

A. *The heavy casting which forms the back of the controller casing and the hinged pole-piece.*

Q. Of what use are the arc deflectors?

A. *To direct and confine the arc to a certain space.*

Q. What is the interlocking device for?

A. *To compel the motorman to turn off the power before reversing, aud to lock the controlling cylinder when not in use.*

Q. What is the safety stop for?

A. *To prevent the controlling cylinder being turned past the first running position when a motor is cut out.*

Q. What controls the direction of motion of the motors?

A. *The reversing cylinder.*

Q. Name the controlling fingers or contacts "K" 8 and 9 controller.

A. *T* 1, *R* 1, *R* 2, *R* 3, *R* 4, *R* 5, 19, 15, *E* 1 (*series connection*), *E* 1 (*parallel connection*), *T* 2.

Q. Name the reversing cylinder contacts.

A. 19, *A* 1, *A A* 1, *F* 1, 15, *A* 2, *A A* 2, *F* 2.

NOTE. — K 27 controller has two extra fingers for controlling cylinder, E 2 for series and E 2 for parallel connections.

Q. What would prevent the controlling cylinder being advanced from the off to the succeeding positions?

A. *The interlocking device, a bent finger or loose-contact segment, will prevent the cylinder being turned to first, second, third, fourth, or first run-*

ning position. The safety stop prevents the cylinder being turned past the first running position. Bent fingers or loose contact segments will prevent cylinder being advanced to any of the succeeding positions.

Q. If controlling cylinder could not be turned to the off position, how could you open the circuit and stop the car?

A. *Turn off hood or canopy switch on either end of the car and apply brake.*

Q. How can you distinguish No. 1 motor from No. 2?

A. *Cars equipped with K 8 and 9 controllers have a short jumper in No. 1 between E 2 and T 2 terminal. No. 1 motor is on the same end. K 27 controller main light switch is on No. 2 end.*

Q. Describe the changes effected in resistance and motor connections when advancing the controlling cylinder of K 8 or 9 controllers.

A. *1st point: Motors in series and in series with resistance 1.*
2d point: Motors in series and in series with resistance 2.
3d point: Motors in series and in series with resistance 3.
4th point: Motors in series and in series with resistance 4.
(1st running position.) 5th point: Motors in series, all resistance cut out.
6th point: Motors in parallel and in series with resistance 2.
7th point: Motors in parallel and in series with resistance 3.
8th point: Motors in parallel and in series with resistance 4.
(2d running position.) 9th point: Motors in parallel, all resistance cut out.

Q. Describe the changes effected by advancing the cylinder of a K 27 controller.

A. *1st point: Motors in series and in series with resistance 1.*
2d point: Motors in series and in series with resistance 2.
3d point: Motors in series and in series with resistance 3.
(1st running position.) 4th point: Motors in series, all resistance cut out.
5th point: Motors in parallel and in series with resistance 2.

6th point: Motors in parallel and in series with resistance 3.
7th point: Motors in parallel and in series with resistance 4.
(2d running position.) 8th point: Motors in parallel, all resistance cut out.

NOTE. — When starting, take particular notice whether the motors take their proper speed on all positions of the controlling cylinder, and if not, notify the proper authorities.

Q. Which motor is cut out of circuit when changing from series to parallel?

A. *Motor No. 2.*

Q. Why are the motors connected in series?

A. *To reduce the strength of the current.*

Q. Why are the motors put in parallel or multiple?

A. *To increase the strength of the current and the speed of the motors.*

Q. What is the starting resistance for?

A. *A device placed in the motor circuit to reduce the amount of current when starting motors.*

NOTE. — When the controlling cylinder is advanced to the first point, all starting resistance is cut in circuit, and as the motors gain speed, the resistance is cut out gradually by advancing the cylinder one point at a time.

Q. How are the motors protected when the starting resistance is cut out?

A. *By their counter-electro-motive force.*

Q. If the resistance is cut out too fast when starting, how would it affect the motors?

A. *The motors would be overheated, the insulation would burn or bake; also cause arcing at commutators.*

NOTE. — When a motorman cuts out the resistance too fast or uses power on down grades he abuses his motors and they become overheated.

Q. If controlling cylinder is allowed to rest on resistance points a longer time than is necessary to start the motors, what effect would it have on the resistance?

A. *The resistance would be overheated.*

NOTE. — If resistance is overheated, circuit-breakers must be turned off and car be conveyed to Depot. (See instructions relating to fire.)

Q. If controlling cylinder is turned off slowly, what would be the result?

A. *A heavy arc would be formed between the controlling fingers and contact segments.*

NOTE. — Never turn controlling cylinder from a higher to a lower point.

Q. If a car is at rest and the controlling cylinder is turned to the first point and immediately turned off before the motors have attained any speed, what injury is done?

A. *Contact segments and fingers would be blistered and set finger board afire, as the resistance in circuit without the counter-electro-motive force of the motors would be so small that a very large current would be flowing, causing an arc too intense for the blow-out magnet to break instantly.*

Q. Why is it necessary for the motors to attain about half speed before turning the controlling cylinder from series to parallel connections?

A. *By allowing the motors to run at half speed or faster, they generate a strong counter-electro-motive force, which assists the resistance in protecting the motors against the action of a large current while changing from series to parallel.*

Q. Why is it necessary to move the controlling cylinder quickly while changing from series to parallel?

A. *To prevent overloading No.* 1 *Motor while the change is being made.*

Q. If the controlling cylinder is advanced to the first running position and the motors fail to start, how would you locate the open circuit?

A. *Cut in the lights. If the lamps light, examine canopy switches and fuses; if switches and fuses are all right, cut out the motors in succession in*

order to locate the defective one. If the lamps fail to light, examine automatic or ground switches; if switches are on, examine plow leads.

NOTE. — When a motor is cut out, the car must be coupled to another car and conveyed to the Depot, the motorman on the disabled car assisting on heavy grades with the motor in service.

The objection to operating a car with one motor is, when starting, a large current is flowing at double the pressure required for each motor when starting in series.

Q. If the motors fail to start in series, why are you not allowed to advance controlling cylinder to parallel connections?

A. *If one or both motors were cut in circuit on the parallel connections there would not be enough resistance in circuit to protect them against the action of a large current when starting.*

Q. What must be done before leaving the platform of a car?

A. *Lock the controlling cylinder and take off both handles.*

Q. What must be done before attempting any repairs?

A. *Turn off both automatic or ground switches.*

NOTE. — The automatic switch is a magnetic blow-out circuit-breaker, placed in the motor circuit to protect the electrical equipment by opening the circuit when the current, through abuse or other causes, becomes too large.

Q. What is a fuse?

A. *A safety device designed to break the motor circuit when an excessive current is flowing. It breaks the circuit when heated to a temperature at which it melts.*

NOTE. — The fuse is a protection against fire because it melts at such a low temperature that it is impossible for the circuit to get heated to a point that will set fire to inflammable material.

Q. Name the principal parts of an electric motor.

A. *Magnet frame. Pole-pieces. Field coils. Field leads. Axle* jumper. *Armature. Armature coils. Armature core. Armature leads. Armature shaft. Armature pinion. Brush yoke. Brush-holders. Brushes.*

Q. What is a field magnet?

A. *That part of an electric motor which develops the magnetic field.*

Q. What is an armature?

A. *That part of an electric motor which is revolved between pole-pieces of the field magnets.*

Q. What is an armature pinion?

A. *A toothed wheel placed on the armature shaft of a street car motor for engaging the teeth of the reduction gear.*

Q. What is a commutator?

A. *A device for conducting currents of electricity to and from the armature coils.*

Q. What is a brush?

A. *A piece of carbon which forms a sliding contact on the segments of the commutator.*

Q. What is an armature lead?

A. *A wire connected to the brush-holder.*

Q. What is a field lead?

A. *A wire connected to the field coils.*

Q. Name the four leads connected to No. 1 motor.

A. *A* 1, *A A* 1, *F* 1, *E* 1.

Q. Name the four leads connected to No. 2 motor.

A. *A* 2, *A A* 2, *F* 2, *E* 2.

Q. If any of the circuit-breaking devices or electrical connections are burning, what must be done?

A. *Turn off automatic or ground switches and disconnect plow leads, then push or trail car to Depot.*

NOTE. — When any part of the electrical equipment of a car is afire, or if there is any sign of fire, such as smoke, the odor of burnt rubber or charred wood, the automatic switches must be turned off and plow leads disconnected, then have the car pushed or trailed to Depot. Switches must not be reset or plow leads connected while car is on the road.

Q. What must be done if automatic switches blow twice in succession?

A. *See that automatic switches are turned off and have car conveyed to Depot.*

Q. If a grounded No. 2 motor was in motion, how could it be stopped?

A. *Reverse, stopping the momentum of car with the brake, then cut No. 2 motor out, or turn off automatic switches and have car conveyed to Depot.*

Q. What is meant by bucking motor?

A. *A motor acting in opposition through some defect. The motor must be located and cut out of circuit, or turn off automatic switches and have car conveyed to Depot.*

NOTE. — Motormen must familiarize themselves with the action or sounds made by the car when starting and running; if anything unusual is noticed, they should endeavor to locate and remedy the cause.

Q. If necessary to stop by reversing, to what position must the controlling cylinder be turned?

A. *To the first position, as all resistance is in circuit to cut down the current.*

Q. If, when reversing, the circuit is opened, what would you do to stop the car?

A. *Put the motors in parallel.*

Q. If descending a grade with the brakes out of order and cut off from the line, how could you stop the car?

A. *Turn off the canopy switch, reverse and put the motors in parallel.*

The motors then act as generators, driven by the momentum of the car, which is not force enough to turn the armature against the induced action of the fields.

NOTE. — To stop a car equipped with four motors, simply reverse.

Q. When cut off from the line how would you stop if the car is moving backward on a grade and you found it impossible to stop with the brake?

A. *Turn off canopy switch and advance controlling cylinder to parallel connections.*

Q. How can a car be stopped when descending a grade with a motor cut out, brakes out of order, and cut off from the line?

A. *Turn off canopy switch, cut in the defective motor, reverse, turn the controlling cylinder to parallel connections, then cut the defective motor out. The motor in service will stop the car.*

Q. How can a car be stopped when moving backward on a grade with a motor cut out, brakes out of order, and cut off from the line?

A. *Turn off canopy switch, cut in the defective motor, advance controlling cylinder to parallel connections, then cut the defective motor out. The motor in service will stop the car.*

NOTE. — Except to prevent injury to life or property, emergency stops must not be made.

Q. How are series-wound street railway motors made to act as generators?

A. *Reverse the armature connections or change the direction of rotation of the armature.*

Q. If the lamps fail to light when the main light switch is closed, what is usually the cause?

A. *The light fuse which is located on the inside of the cover of main light switch is probably blown.*

Q. How can you locate a defective lamp?

A. *Usually the glass will be discolored; if not, tap the lamps lightly, which will cause the broken parts of the filament to come in contact and arc.*

Q. How is the current of electricity conducted from underground conductors to the motors?

A. *By a device known as the plow, fitted with two springs which press sliding contacts or shoes against the underground conductors. Flexible fuse wire connects sliding contacts to wires enclosed in the plates which form the body of the plow. These wires or leads are connected to wires T 1 and T 2.*

Q. When the plow is grounded, what should be done?

A. *Turn off ground or automatic switches, and convey the car to a plow hatch, where plow can be removed.*

NOTE. — If plow springs are broken, turn off automatic switches and have the car conveyed to the Depot. (Remove the plow at a hatch if necessary.)

Q. What indicates the break in the underground conductor?

A. *A long white mark on the surface of the street, running from tram rail to tram rail.*

Q. What mark is used to show that the break has been passed?

A. *A short white mark running from slot rail to tram rail of the left side.*

Q. Why is it necessary to turn off power at the marks which indicate the break in the underground conductors?

A. *To open the circuit in the controller so that the arc will be formed between the contacts and instantly blown out by the blow-out magnet.*

Q. What is usually the result if power is not turned off at the marks which indicate the break in the underground conductors?

A. *The circuit will be open in the conduit between plow shoes and underground conductors. The heat caused by the arc weakens the plow springs, burns off plow fuses and sets plow-board afire.*

ELECTRICAL TERMS

Arc. — An electric current flowing across the air gap or space between the points of contact.

Closed Circuit. — A circuit is closed when its conducting parts are so connected as to allow the current to flow.

Open Circuit. — A circuit is open when its conducting parts are disconnected in such a manner as to prevent the current from flowing.

Ground Circuit. — A circuit in which the ground forms part of the conducting path.

Short Circuit. — A short cut made by the current to a path outside of the regular circuit.

Cut Off from the Line. — Open circuit. Car disabled by an open circuit.

Electro-Motive Force. — The pressure that causes an electric current to flow.

Counter-Electro-Motive Force. — The pressure generated in the armature, causing a current of electricity to flow in opposition to the current supplied to run the motor.

Insulation. — Material used to confine currents of electricity to certain channels.

ABBREVIATIONS

D. C.	Direct Current.
A. C.	Alternating Current.
E. M. F.	Electro-Motive Force.
C. E. M. F.	Counter-Electro-Motive Force.
R.	Resistance.
+	Positive.
−	Negative.
A. +	Positive Armature Lead.
A. A. −	Negative Armature Lead.
F. +	Positive Field Lead.
E. −	Negative Field Lead.
T. 1 +	Positive Main Wire.
T. 2 −	Negative Main Wire.

DONT'S

Don't cut the resistance out too fast.

Don't turn controlling cylinder from a higher to a lower point.

Don't turn controlling cylinder to first point and off when it is possible to avoid it.

Don't run the car if motors fail to start when controlling cylinder is turned to first and second points.

Don't fail to have your motors running at half speed when changing from series to parallel.

Don't ascend grades with motors in series.

Don't use power on down grades.

Don't wait until fire drives you from the platform; act when you notice any indication of fire, such as smoke, the odor of burnt rubber or wood.

Don't fail to turn off automatic switches and disconnect plow leads when fire is first noticed.

Don't use water to extinguish the fire when plow leads are connected.

Don't use water at any time if the fire can be extinguished in any other manner.

Don't tell passengers that the car is afire. Say car is disabled.

Don't fail to see that both automatic switches are turned off after they blow the second time.

Don't attempt any repairs before turning off both automatic switches.

Don't fail to reset automatic switches when through with repairs.

Don't experiment with the car.

Don't leave the platform without taking both controlling handles with you.

"NOARK" FUSE

This contrivance is manufactured by the H. W. Johns-Manville Company of New York. Some of the largest roads in the country are now using this style of fuse box.

The slate block, to which is attached the two binding-posts, is firmly fixed and protected in a solid well-japanned cast-iron box as shown in the illustration. This box has a hinged cover and spring-snap catch, which allows the cover to swing back and makes the inside of the box easy to get at, and the insertion of a fuse but a moment's work.

The "Noark" fuse is a vast improvement over the old-time ordinary bare wire or lead fuse for several reasons, chief among which are the following: They do not rupture with a loud report and a heavy flash which is so liable to frighten the

passengers, causing them to jump off of the car while it is in motion, often resulting in a damage suit against the company; they do not frighten horses which might be near the car, and cause runaways; they do not blister the varnish and paint and blacken up the sides of the car. This is a decidedly bad feature with the uncovered fuse, as sometimes before a car has been in service a week, after having been repainted and revarnished, it is all blackened and charred up by the blowing of old-style fuses.

A splendid advantage with the "Noark" (see cut) fuse is that there are no thumbscrews to remove to replace a fuse.

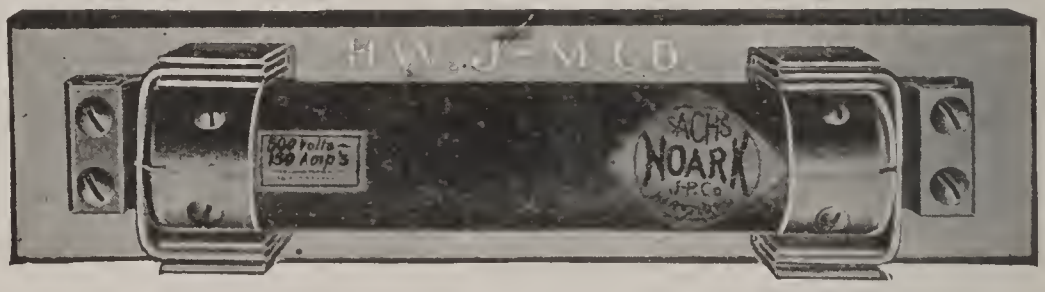


Fig. 35. — Cut Showing "Noark" Fuse.

The fuse is simply snapped into connection with the slip contacts on the block which connect with the contacts at the end of the tube. All motormen who have had experience in replacing the old-time fuse know how very difficult it is to insert a fuse properly in cold weather, when the fingers are benumbed with cold; and oftentimes the fuse is not properly inserted on this account, and before the car has gone any distance the fuse has blown again, which necessitates the insertion of another fuse.

The "Noark" fuse has a fusible conductor enclosed by a tube, and a peculiar filling, known only to the manufacturers, entirely surrounding the conductor. Any arc or flash under

short circuit, or from any other cause whatever, is entirely done away with by virtue of the enclosing casing and peculiar action of the surrounding filling. Owing to the arrangement of the

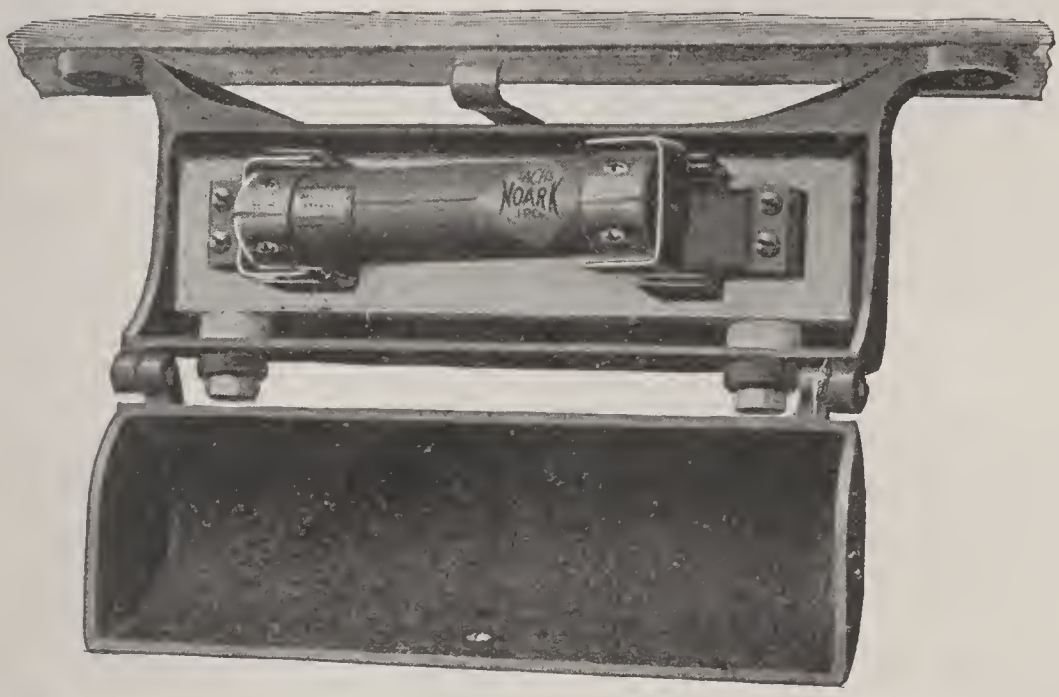


FIG. 36 — Cut showing "Noark" Fuse Box, with the Fuse Inserted, and Cover Thrown Back.

surrounding material the blowing time interval at any period during the life of the fuse remains practically constant, and simply varies in an inverse ratio to the amount of excess current above its rated capacity.

A blown fuse should be preserved by the motorman and turned in to the proper person, as these blown fuses are returned to the manufacturers to be refilled and returned to the railroad company at a very much less cost than that of a new fuse, and it is therefore to the advantage of the railroad company that all blown fuse be preserved and turned in as suggested.

Motormen should also be careful about the insertion of a

"Noark" fuse, pushing the fuse well home into the clip contact, in order that they may get the full benefit of the carrying capacity of the contact clips.

The last feature we would point out is that of the indicator. When a fuse is blown the indicator on the outside of the tube makes the fact known to the motorman. A high-resistance shunt in circuit with the main fuse is used which blows simultaneously with the fuse and leaves a small blackened mark on the outside of the tube as an indication of the blowing.

POWER BRAKES

At the present time in electric railway practice, with the use of methods and equipments which are approaching steam railway standards, the application of power brakes is becoming quite general. The primary cause of the introduction of power brakes was for the comparative degree of safety in operation of cars of greater weight. When cars are equipped with power brakes a much higher speed can be attained with practical safety. There are two classes of power brakes operated by air, namely:

(*a*) Straight Air Brakes.

(*b*) Automatic Air Brakes.

Where one or two cars constitute a train, straight air is generally used, but where several cars constitute a train, automatic air brakes are used.

STRAIGHT AIR BRAKE

A Straight Air Brake equipment for Electric Traction consists of the following parts:

A Motor Compressor.

Pump Governor.

Reservoir.

Brake Cylinder.

2 Brake Valves or Rotary Valves.

2 Air Gauges (Duplex usually).

Cut-out Cocks.

Drain Cocks, also necessary piping for making proper connections.

AIR COMPRESSOR

An air compressor supplies the compressed air. It consists of two plungers, operated by a crank-shaft, the action being similar to that of a suction pump. While the air is drawn in by one of the plungers, the opposite plunger compresses the air into a chamber which is in connection, through a system of piping, with the reservoir, which is the storage chamber. The compressor is driven by a motor. The pinion of the armature intermeshes with the driving gear, which is secured to the crank-shaft.

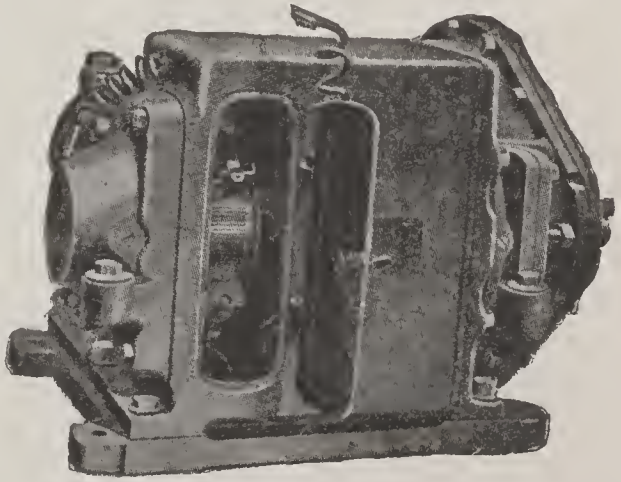


FIG. 37. — W. H. Compressor.

PUMP GOVERNOR

A pump governor is in connection with the reservoir pressure; it also having a metallic connection with the motor circuit for operation which is automatic.

ACTION OF PUMP GOVERNOR

When a certain predetermined maximum pressure is reached in the reservoir, a pneumatic valve contained in the governor operates so as to open the motor circuit. When the reservoir pressure has been reduced to a certain predetermined minimum amount, the governor closes the circuit of the motor, allowing the compressor to operate until the maximum pressure has been attained, when the governor again operates as previously mentioned, stopping the compressor until another reduction in pressure has occurred.

BRAKE CYLINDER

A brake cylinder consists of a cylindrical vessel containing a piston and rod which is attached to a suitable system of levers and rods of the brake mechanism. On the push-rod side of the piston is a spiral spring for returning the piston to its normal position when the brakes are released.

BRAKE VALVES

The brake valve is a device interposed between the reservoir and brake cylinder by means of which (1) air is allowed to flow from the reservoir to brake cylinder for applying the

brakes; (2) the pressure in brake cylinder is allowed to flow to atmosphere for brake release.

AIR GAUGE

The air gauge is a device for registering the pressure of main reservoir or brake cylinder. This device is usually tapped to the pipe on the side of reservoir, from which the air is taken for service.

CUT-OUT COCKS

The cut-out cocks are so situated in the system to cut out either the reservoir or brake cylinder.

DRAIN COCKS

A drain cock is inserted in the reservoir for the purpose of draining water from the same.

BRAKE APPLICATION

When an application of brakes is made the air flows from the reservoir through brake valve to brake cylinder, pressing the piston and rod forward, which is attached to levers of the brake apparatus, causing the brake shoes to be brought in contact with the wheels of truck, retarding their momentum.

RESERVOIR

An air reservoir is a chamber for the purpose of storing air for use in the brake system. It consists of a cylindrical chamber composed of galvanized iron to withstand a certain number of pounds pressure.

OPERATION OF STRAIGHT AIR BRAKES

In charging the system, see that all drain cocks are closed, also that brake valves are in a release position with the valve to be operated; the opposite valve to be on lap position. Start compressor by closing a snap switch of compressor motor which is usually in the trolley circuit. After the maximum pressure has been obtained, the motor circuit is opened automatically by the governor.

SERVICE APPLICATION

When making an application of air for braking, move the brake-valve handle to service position, which allows the air to flow from the reservoir to brake cylinder.

EMERGENCY APPLICATION

An emergency application is obtained by moving brake-valve handle to the extreme right, which allows an increased volume of air to flow from reservoir to brake cylinder, minimizing the amount of time required for a full application, and stop.

RELEASE

The release of brakes is obtained by moving brake-valve handle to the extreme left, which allows the pressure of air to flow out of brake cylinder to atmosphere.

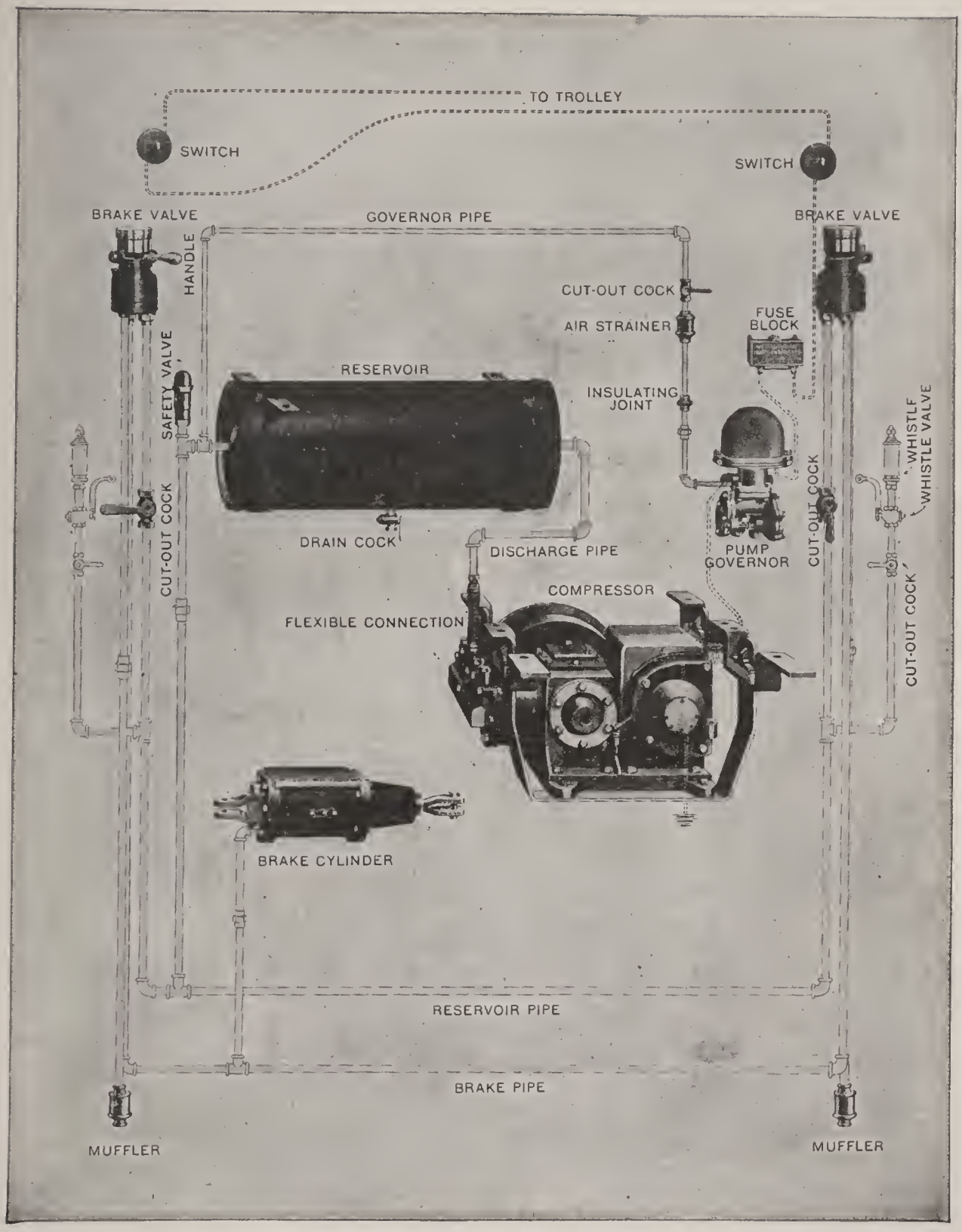

TO TROLLEY
SWITCH
SWITCH
BRAKE VALVE
GOVERNOR PIPE
BRAKE VALVE
HANDLE
CUT-OUT COCK
AIR STRAINER
FUSE BLOCK
SAFETY VALVE
RESERVOIR
INSULATING JOINT
WHISTLE
WHISTLE VALVE
CUT-OUT COCK
CUT-OUT COCK
DRAIN COCK
DISCHARGE PIPE
PUMP GOVERNOR
CUT-OUT COCK
COMPRESSOR
FLEXIBLE CONNECTION
BRAKE CYLINDER
RESERVOIR PIPE
BRAKE PIPE
MUFFLER
MUFFLER

FIG. 38.

LAP POSITION

When the brake-valve handle is placed in lap position, all parts leading to reservoir and brake cylinder are blanked by the rotary valve.

PROPER METHOD OF BRAKE-VALVE OPERATION

First. Place the brake-valve handle in full release position when running.

Second. When a brake application is desired, place brake-valve handle in service position, allowing a flow of air from reservoir to brake cylinder. When the speed of car has been sufficiently retarded, the brake-valve handle should be placed in lap position. As the speed of car diminishes, the operator should graduate the release. This is accomplished by moving the brake-valve handle from lap to release position, which allows the pressure air of cylinder to escape to atmosphere. But replace the handle in lap again so as to retain a portion of the pressure in brake cylinder. Usually in making a full stop two graduated releases are used. Just prior to the final stop of car, move the brake-valve handle to full release until the pressure has fully escaped from the brake cylinder. Should the car be on a grade, a sufficient pressure must be held in brake cylinder to retain car until ready to start again, when the brake-valve handle is moved to full release for car to be operated.

EMERGENCY APPLICATION

An emergency application is used only in extreme case of emergency, to avoid accidents. This is obtained by moving the brake-valve handle to the extreme right, allowing a heavy

volume of air to flow to brake cylinder. When using this position the cylinder pressure ought not to be released until all danger is past.

LAYING UP OF CAR

When car is placed in car house the motor of compressor should be cut out, also the reservoir drained of water through drain cock.

COMPRESSOR MOTOR

An air-compressor motor is of the multipolar type, having two fields and active poles, and two consequent poles. The field coils or solenoids are in series connection. The armature is of the drum type, having two brushes in circuit. The armature is in series with field coils. The windings of the entire motor circuit allow of a direct connection from trolley to ground, with a 550- or 650-volt circuit.

DIRECTION OF CURRENT WITH MOTOR CIRCUIT

The current passes from the trolley wire through a switch and fuse, through a wire connecting with a brush-holder of armature circuit, passing through the armature circuit to opposite brush-holder through a wire in connection with a field terminal, passing through field coil to opposite terminal, through a wire connecting with the terminal of the second field, passing through circuit of same, to opposite terminal, through a wire, which is grounded, connecting with motor frame or in connection with the main ground wire of motor circuit.

DEFECTS

When a pump governor becomes defective and cannot open the circuit of motor, the operator can cut out same by throwing motor-circuit switch. The circuit can be operated by motorman, by his cutting in the switch to start compressor, and keeping it in until the pressure is at a maximum, then cutting out switch again, and proceeding in this manner until he has reached the car's destination. Providing the operator is on the opposite end from cut-out switch he can allow the conductor to perform this duty.

FUSE

When a fuse is blown in circuit, replace by another. Should the fuse again blow, undoubtedly a ground or short circuit has occurred in the motor circuit, unless the fuse is of a lower rating than the circuit calls for.

INSTRUCTIONS TO MOTORMEN FOR OPERATING PRICE HYDRAULIC BRAKE

This brake has an operating lever which is located close to the dash between the hand-brake staff and the motor controller. To apply the brake, pull the lever slowly for an easy stop and quickly for an emergency stop, and ease off the pull on the lever slightly just before the car comes to a stop, same as is done with the hand brake.

When starting up on a grade do not ease off the pull entirely, but hold the brake on until ready to start the car. If the brake is released on a grade the car will run backwards, but it can

be brought to a stop by applying the brake, same as when the car is running down the grade.

The lever is provided with a ratchet and pawl, but these should not be used till after the car comes to a stop and when it is desired to hold the brake on.

Before leaving the car platform always set the hand brake.

INSTRUCTIONS FOR MOTORMEN IN OPERATION OF THE CHRISTENSEN STRAIGHT AIR BRAKE

First. To start up the compressor, close the canopy switch. This will automatically close the governor, so that the current will pass from trolley to ground through the motor driving the compressor.

Second. Should the compressor refuse to work under these conditions, the fuse may be blown. If so, do not put a heavier fuse in than is suited for the size of the compressor. If the fuse is all right, the trouble is elsewhere, and you should try to locate it if you can do so; if not, you ought to report the matter to the proper authority.

Third. All the stop-cocks on the train pipe, except on the front and rear end of the car, should be open. When open the handle stands crosswise to the pipe, and when closed it stands parallel with it.

Fourth. To cut out a standard governor, close the $\frac{1}{4}$-inch stop-cock so that the T-handle stands crossways with the pipe and then move the governor plunger so as to make contact and close the circuit. The compressor can now be started and stopped by the hand switch in the canopy, but you should take care not to forget to start and stop the compressor so as to keep

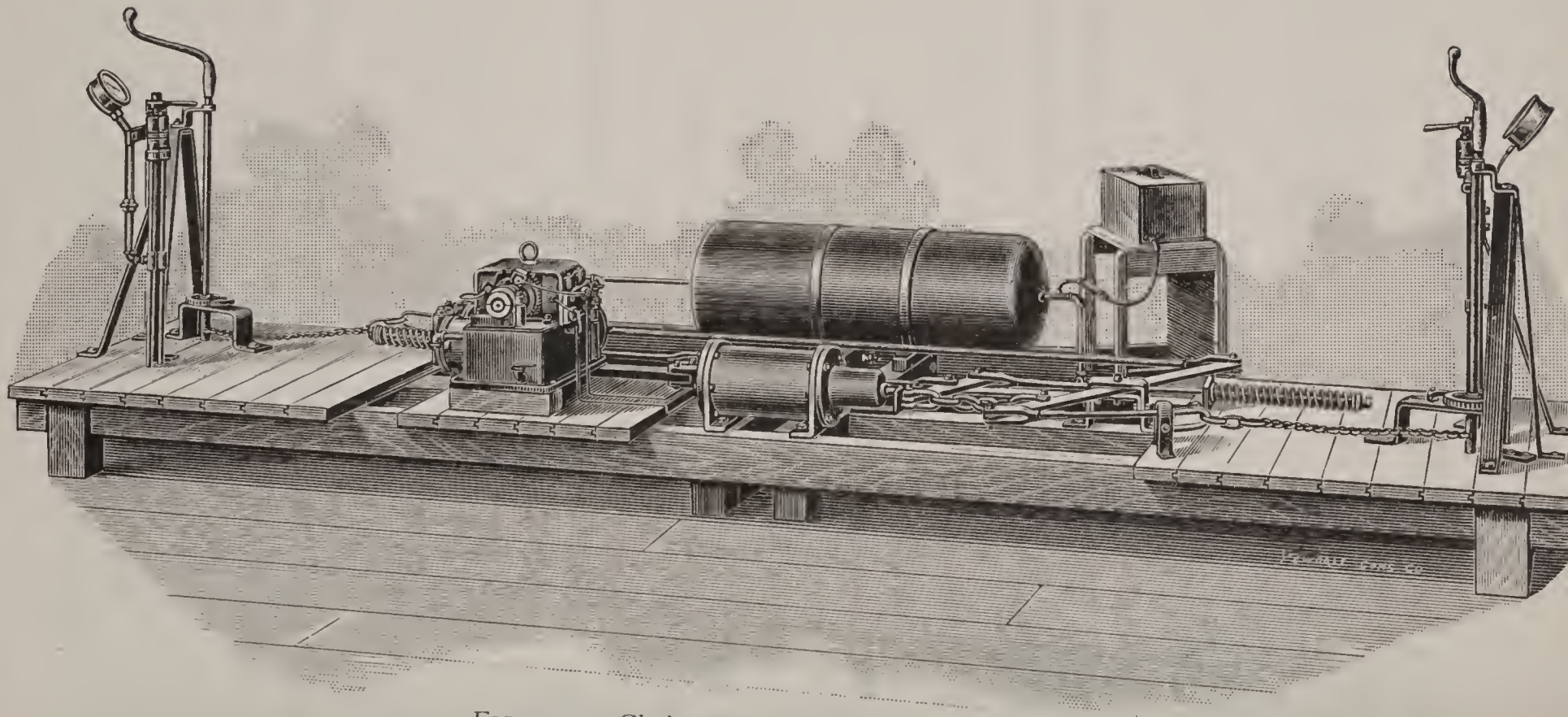


FIG. 39. — Christensen Air-brake Equipment.

the pressures within the desired limits of 70 lbs. minimum and from 80 to 90 lbs. maximum.

ENGINEER'S VALVE

Lap Position. — The engineer's valve, in direct control of the motorman, is made with a detachable handle which is only removable in what is known as the lap position, in which position the valve is neutral in the same manner as the main controller is by moving the reverse handle.

Service application of the brakes is effected by moving the handle of the engineer's valve to the first notch to the right. As soon as sufficiently hard pressure is brought against the wheels, the handle may be moved back into lap position, whereby the brakes remain set at that pressure. If it is desired to set the brakes a little harder, repeat the operation. By moving back to the lap position without releasing, the handle may be removed and the brake released from the other end of the car. This feature is very valuable where the terminus is on a grade.

Slow Release of the Brakes. — By removing the handle from lap position to the first notch to the left, a slower release of the brakes is effected, which release may be checked in the same way by moving the handle back to lap position, the same as in the service application of the brake.

Emergency Application. — This is effected by moving the handle from lap as far as it will go to the right, in which position a large passage is afforded to allow compressed air to travel from the main reservoir to the brake cylinder, and the application of the brakes is practically instantaneous. This kind

of an application should not be made except when absolutely necessary.

Quick Release. — By moving the handle from lap position to the left as far as it will go, a quick release is effected in the same manner as a quick application by establishing a large opening from the brake cylinder to the atmosphere, whereby the pressure escapes quickly from the brake cylinder, thereby letting off the brakes in a very short space of time.

Running Position. — The handle of the engineer's valve should always, when the brakes are not being applied or released, be on the first notch to the left or that of slower lease.

Brake Leverage. — The leverage and total pressure on the brake cylinder is so proportioned that under ordinary circumstances, with a dry rail, the wheels cannot skid. If the rail is in bad condition for stopping, the leverage and pressure, being the same as under normal conditions, would probably skid the wheels if the brake cylinder be charged with the full pressure. In such instances care should be taken not to slide the wheels by not introducing too much pressure to the brake cylinder. If the wheels slide, which can be instantly felt, the handle is moved over to slow release, letting out air until the wheels revolve, then back to lap, and release again just before the car comes to a dead stop, so as to prevent a disagreeable chuck, which follows if a car comes to a dead stop with the brakes applied.

Figure 39 shows a Christensen air-brake equipment, consisting of exactly the same parts as are mounted underneath the car, with the air brake and hand brake connected up in the same manner as it is in actual operation.

INSTRUCTIONS TO MOTORMEN IN THE OPERATION OF THE MERRITT AIR BRAKE COMPANY'S SYSTEM

Starting Car. — Before starting car, motorman should first ascertain, both by consulting the air gauge and making at least one brake application, that he has air pressure with which to control the movement of the car.

Motor Compressor. — To start the motor compressor, close the air-brake switch, when the pump will continue to run until the maximum pressure is reached.

Fuse. — Should the compressor fail to start, see that the fuse is not blown. If it is, do not put in a larger fuse than is furnished for the motor compressor. Should the fuse again blow, in all cases report the same to the person in charge at the depot.

Governor. — Should the governor (or controller) fail at any time to work when on the road, cut it out by closing the valve in the controller pipe. See that the cross-head is in contact with the terminals, and govern the air pressure with the air-brake switch, taking care to throw the switch when the maximum and minimum pressures are reached. Report same when the car house is reached.

Engineer's Valve. — The engineer's valve is so constructed that the amount of brake pressure is automatically controlled according to the movement given the operating handle.

The running position of the engineer's valve is central, or when the operating handle is in the removable position.

When you want to apply the brake, pull the handle to you until you feel the brake take hold. When you want to release the brake push the handle from you.

Service Stops. — To make a service stop, pull the handle to you until you feel the car coming to a stop, as with the hand brake, and should the car not respond as desired, a further movement of the handle will admit more air to the brake cylinder.

As the car comes to a rest, release the brake pressure as with the hand brake, until there remains in the brake cylinder only enough pressure to hold the car.

Emergency Stop. — Emergency application should be made only when absolutely necessary. For an emergency stop pull handle to you, first to bring the brake shoe in contact with wheels, and then pull the handle to extreme travel when full reservoir pressure will be admitted to the brake cylinder.

Sliding Wheels. — Should the wheels slide on account of bad rail or other causes, release the air until the wheels begin to revolve, and then apply the air slowly until the required pressure is obtained. Too much brake pressure will slide the wheels every time. Don't fail to see that you have air before starting the car.

Don't take the car out before trying the air brake.

Don't use larger fuse than is furnished for the motor compressor.

Don't try to start the car with the air brake set.

Don't use the air-brake handle upside down, because you may leave the valve in such a position that the brake cannot be set from the other end of the car when you change ends.

Don't make more than one application when stopping the car.

Don't fail to release the brake as the car comes to a stop.

Don't apply more air when the wheels slide. Release and use less.

Don't make emergency application unless absolutely necessary.

Don't fail to put air-brake handle where it belongs.

Don't leave the car for any length of time without applying the hand brake.

Don't fail to report a poor braking car to the person in charge of shop.

AUTOMATIC AIR BRAKE SYSTEM

An Automatic Air Brake System consists of the following parts:

A Compressor.
2 Main Reservoirs.
1 Auxiliary Reservoir.
2 Brake Valves for each unit.
1 Brake Cylinder.
1 Brake Slack Adjuster.
1 Triple Valve.
1 Slide Valve Feed Valve.
1 Safety Valve.
2 Duplex Gauges.
1 Conductor's Valve.
1 Emergency Valve.

Cut-out Cocks necessary for the entire system; also necessary piping.

The compressor, reservoirs, brake cylinders, safety valves and gauges are the same as those used in a straight air system.

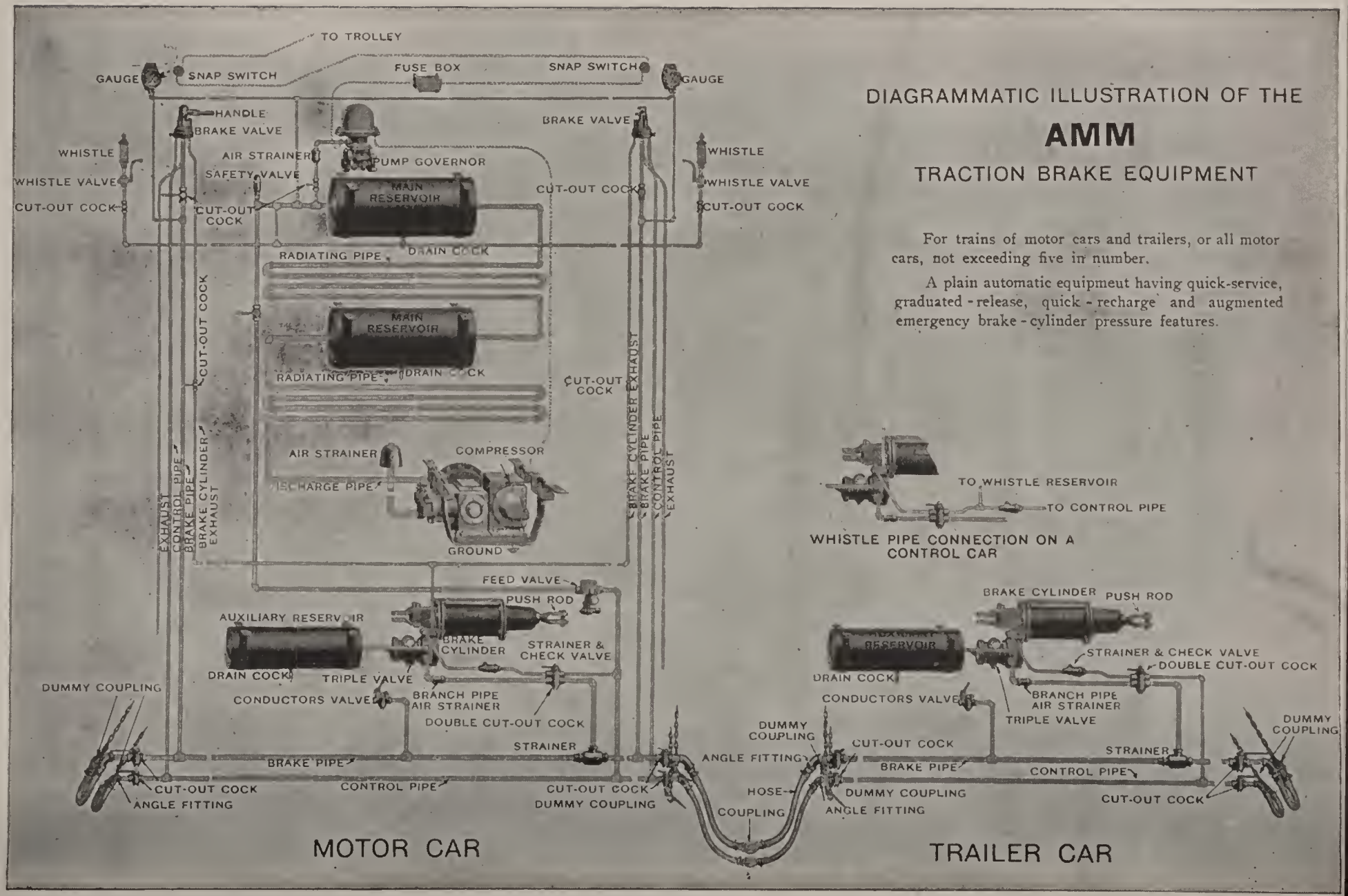


FIG. 40. — Westinghouse A M M Traction Brake.

BRAKE VALVES

The brake valve is interposed between the control pipes and brake-pipe line. This valve performs two functions.

First. To charge the brake-pipe line and aulixiary reservoirs for brake release.

Second. To allow a reduction in brake-pipe line pressure, for brake application, from auxiliary-reservoir pressure.

BRAKE SLACK ADJUSTER

Is an automatic device for taking up the slack in brake-rigging caused by brake-shoe wear. This device consists of a pneumatic tube which forces the piston and engages a pawl with a ratchet nut which turns upon a screw thread of pull bar in connection with brake mechanism. The air pipe of this device is connected to the brake cylinder and is only active upon a predetermined travel of brake-cylinder piston.

CATECHISM OF SLACK ADJUSTER

Q. What is an automatic slack adjuster?

A. *A device for automatically taking up the slack in brake rigging caused by wear of brake shoe.*

Q. Why should the slack be taken up in brake rigging?

A. *As the brake shoes wear thinner, it allows of a greater piston travel, thereby reducing the brake-cylinder pressure, decreasing the holding power of brakes.*

Q. How is the brake shoe cared for on cars not equipped with a slack adjuster?

A. *The slack in rigging is taken up by hand by the dead levers on one or more connecting rods.*

Q. When a hand adjustment is made can a uniform piston travel be maintained?

A. *No. On account of a difference which exists between a standing and running travel.*

Q. What particular function does the slack adjuster perform?

A. *It adjusts and maintains the piston at a proper running or operating travel regardless of lost travel, when each car is equipped with a slack adjuster. The travel of all pistons will be uniform when brakes are set to slow down or stop train, allowing the same brake-cylinder pressure on all cars of train.*

Q. Is an automatic slack adjuster a complicated device?

A. *No, it is not.*

Q. How is its operation effected?

A. *The piping of slack adjuster is tapped into the brake cylinder at a point allowing a predetermined piston travel. When the piston travel exceeds this, air is allowed to flow to slack adjuster, where a small piston is forced outward, compressing a spring. Attached to piston stem is a pawl which engages a ratchet nut mounted within the casing of adjuster. The ratchet operates a rod having a screw thread which is attached to a brake lever of brake mechanism, thereby decreasing piston travel by pulling brake shoes closer to truck wheels.*

Q. How much is the piston travel decreased with an application?

A. *A fractional part of an inch, about* $\frac{3}{6\,4}$ *of an inch.*

Q. How can the slack be let out when replacing new shoes?

A. *By turning the ratchet nut backward; this being done by hand.*

Q. Is the slack adjuster capable of wearing out a set of shoes, at the same time maintaining a desired piston travel?

A. *Yes.*

TRIPLE VALVE

The triple valve is in connection with the brake-pipe line and auxiliary reservoir. This device performs three functions:

First. To charge the auxiliary reservoir.

Second. To apply the brakes from auxiliary-reservoir pressure.

Third. To release brakes, allowing air to flow from brake cylinder to atmosphere, and recharging auxiliary reservoir and brake-pipe line.

FEED VALVE

A slide-valve feed valve is placed between the main reservoir and control-pipe line so as to establish a constant pressure or nearly so in the control and brake-pipe line. At the present time a small pipe is in connection with the control line and triple valve for a quick recharge of auxiliary reservoirs for allowing graduated releases.

EMERGENCY VALVE

The emergency valve is a device placed in connection with a brake pipe through a pilot valve in the master controller. This valve is governed by a lever attachment of master-controlling handle. As the lever is kept pressed down, the valve is closed; when the lever is released, a port is opened in the pilot valve which allows of a reduction of pressure in brake-pipe line, causing brake application.

CONDUCTOR'S VALVE

The conductor's valve is a device in connection with brake-pipe line, performing similar functions to that of an emergency valve. This device is located on each unit of train and is only used in case of emergency or an accident. The brakes can be applied from any point in the train of each car unit.

SAFETY VALVE

The safety valve is a device for preventing the possibility of overcharging the main reservoir.

DUPLEX GAUGE

A duplex gauge is installed in each cab for indicating the pressure in the main reservoir, also the pressure in the brake-pipe line. The red hand represents main reservoir pressure. The black hand represents control and brake-pipe line pressure.

THE WESTINGHOUSE M TRIPLE VALVE

The type M triple valve is of the *pipeless* type and designed for use in high-speed trains of from one to five cars, performing all the functions as follows:

First. "Quick Recharge" of the auxiliary reservoir.

Second. "Quick Service" application of the brake.

Third. "Graduated Release" of the brake-cylinder pressure.

Fourth. "High-Pressure Emergency" application.

It requires the usual brake pipe, auxiliary reservoir, brake cylinder and exhaust connections; also an additional connection for either a control pipe or a supplementary reservoir.

OPERATION OF THE M-2 TRIPLE VALVE CHARGING

Air from the brake pipe enters the triple valve through passage *a*, *c* and *g* to chamber *h*, thence through feed groove *i* to chamber *R* and the auxiliary reservoir. Brake-pipe air in passage *a* also raises the check valve, passes through ports *y*, *j* and *u* into chamber *R* and the auxiliary reservoir. At the same time air from the control pipe enters the triple valve through passage *x* and flows through port *k* into chamber *R* and the auxiliary reservoir. With these three channels supplying air to the auxiliary reservoir simultaneously, maximum pressure is obtained very quickly.

The rate of charging the auxiliary reservoir through the three channels mentioned is such that a given volume of air can be restored in the auxiliary reservoir in the same interval of time required for the exhaust of an equal amount from the

brake cylinder to the atmosphere, thus maintaining an available maximum braking force at all times.

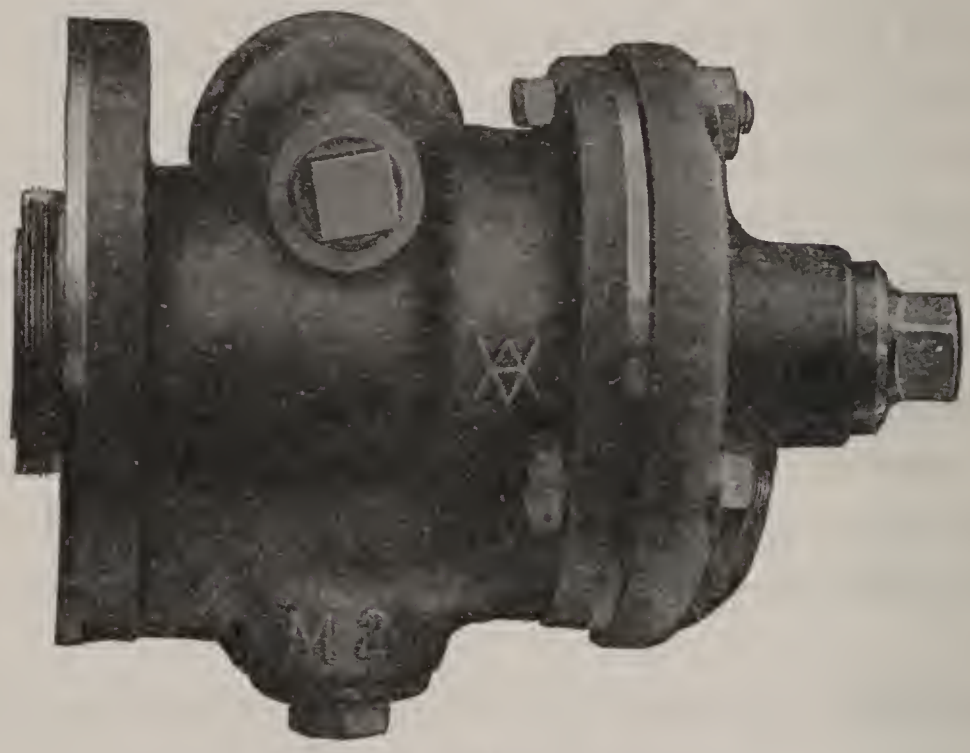


Fig. 41. — The M–2 Triple Valve.

SERVICE APPLICATION

The parts of the triple valve being in charging position, shown in Fig. 42, a service reduction of brake-pipe pressure permits the auxiliary-reservoir pressure to move the piston, slide, and graduating valves to the left to service position, shown in Fig. 43. At the beginning of the service reduction, and before the slide or graduating valves have moved, the check valve in passage *y*, which is held to its seat by the light spring and auxiliary-reservoir pressure, prevents any back flow of air from the reservoir to the brake pipe. The first movement of the piston closes feed groove *i*, and, carrying with it the graduating valve toward the application position, closes charging ports *k*

and *j*, and the exhaust port *m*. With the slide and graduating valves in service position, shown in Fig. 43, air flows from the auxiliary reservoir through ports *z* and *r* to the brake cylinder. At the same time air in the brake-pipe passage *a* raises the check valve, flows through passage *y* into cavity *v* in the graduating valve, thence through ports *q* and *r* to the brake cylinder, thus producing a brake-pipe reduction at the same time that the

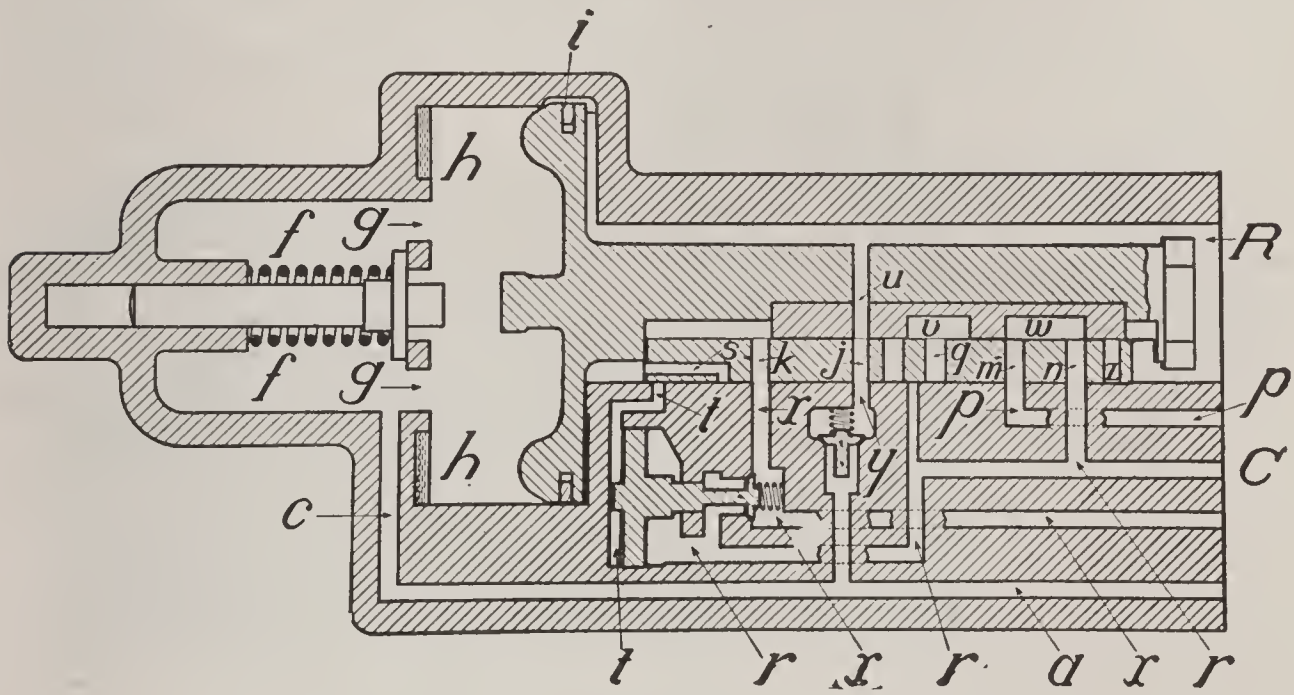


FIG. 42. — The M Triple Valve, Release Position.

auxiliary-reservoir air is flowing to the brake cylinder. This local reduction from the brake pipe to the brake cylinder produces what is known as the "Quick-Service" feature of the triple valve, and results in a quick response of all triple valves to service reductions of brake-pipe pressure.

The relative capacity of the ports conducting the air from the auxiliary reservoir to the brake cylinder, and from the brake pipe to the brake cylinder, is such that the auxiliary-reservoir pressure will be reduced more rapidly than that in

the brake pipe. It is therefore impossible for the piston and graduating valve to remain in service-application position after the brake-pipe reduction through the brake valve is stopped. If the brake-pipe reduction at the brake valve, added to that from the brake pipe to the brake cylinder passing through port *y*, cavity *v*, and ports *q* and *r*, reduces the brake-pipe pressure more rapidly than the auxiliary-reservoir pressure can reduce

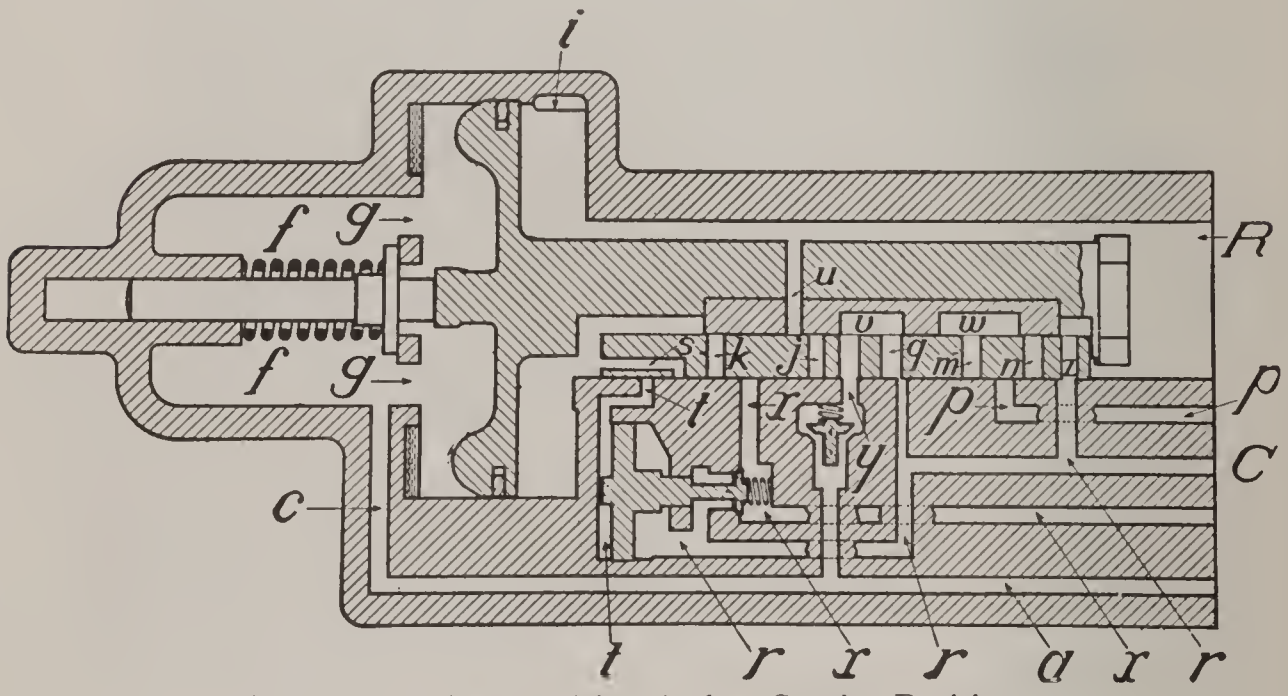


FIG. 43. — The M Triple Valve, Service Position.

by flowing through ports *z* and *r* to the brake cylinder, the triple-valve piston will be moved farther to the left, carrying with it the slide valve. This further movement will cause a partial or complete closure of the quick-service port *q* and *r*, thereby stopping the local brake-pipe reduction without reducing the capacity of ports *z* and *r* from the auxiliary reservoir to the brake cylinder, thus automatically guarding against the rate of brake-pipe reduction being so great as to cause undesired quick action.

When the flow of air from the auxiliary reservoir to the brake cylinder has reduced the pressure in the former to less

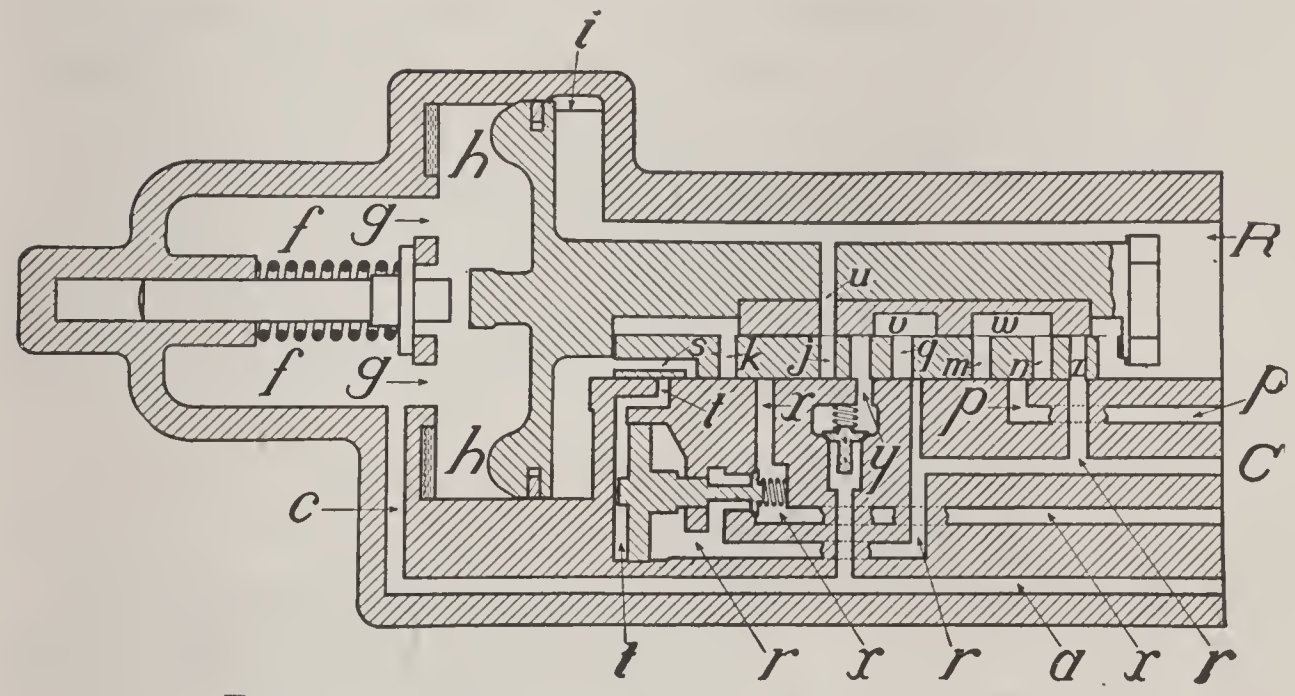


FIG. 44. — The M Triple Valve, Service-Lap Position.

than that in the brake pipe, the piston and graduating valve move to service-lap position, shown in Fig. 44, in which all ports are closed.

RELEASE

The piston being in service-lap position, shown in Fig. 44, raising the brake-pipe pressure moves the piston, slide, and graduating valve to the extreme right to release and charging position (Fig. 42), when the brake-cylinder pressure is exhausted through ports *r* and *n* into cavity *w* in the graduating valve, thence through ports *m* and *p*. At the same time the auxiliary reservoir is being recharged through the two charging ports *y* and *x* and feed groove *i* as described under the heading "Charging."

If the brake-valve handle is moved to release position and left there, the rise of brake-pipe pressure will be more rapid than that of the auxiliary reservoir, causing the piston to remain in release position, resulting in a full release of the brakes.

GRADUATED RELEASE

If only sufficient air is permitted to flow into the brake pipe to move the piston, slide, and graduating valves to release position (Fig. 42), and the brake valve is then returned to lap, the

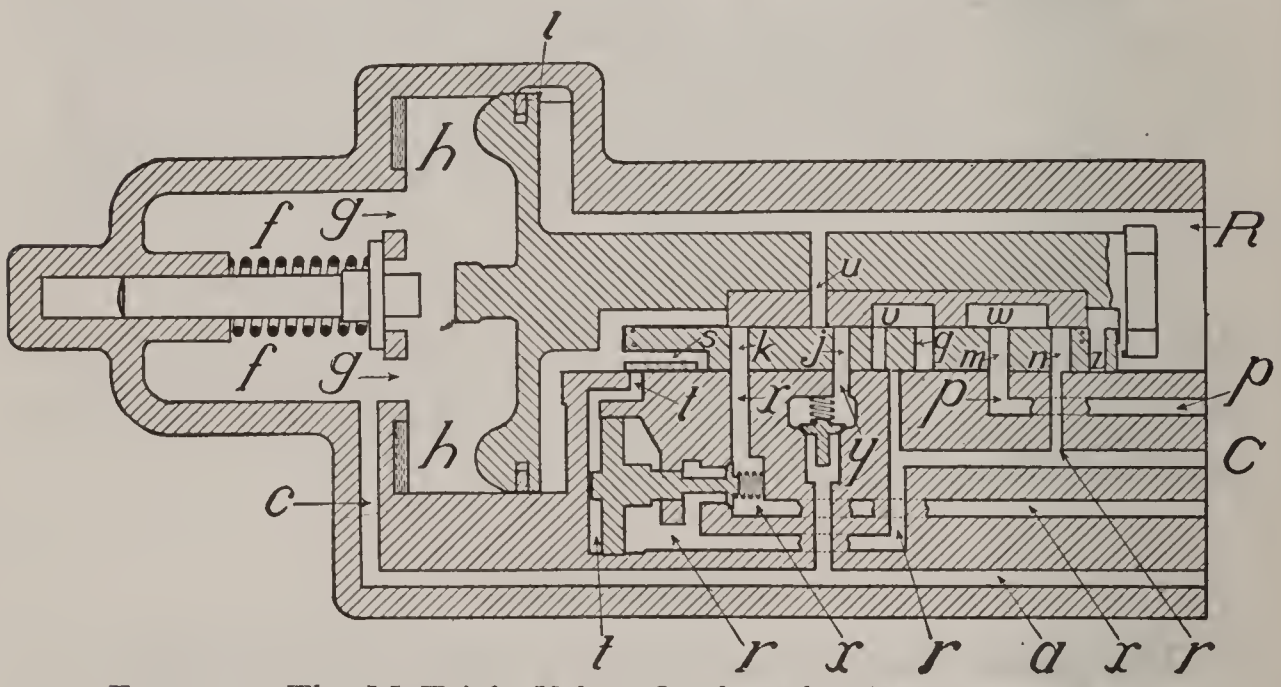


FIG. 45. — The M Triple Valve, Graduated-Release-Lap Position.

flow of air from the control pipe through ports *x* and *k* to the auxiliary reservoir will raise the pressure of the latter slightly above that in the brake pipe and move the piston and graduating valve to the left to "graduated-release-lap" position, shown in Fig. 45, where the graduating valve has closed the exhaust port *m* from the brake cylinder to the atmosphere, ports *x* and *k* from the control pipe to the auxiliary reservoir, and ports *y*

and *j* from the brake pipe to the auxiliary reservoir, thus retaining a portion of the air pressure in the brake cylinder. This operation of the triple valve, "Graduated Release," may be repeated until the brake-pipe pressure has been increased to nearly its maximum. The amount of reduction in the brake cylinder during the graduated release depends upon the amount of increase of pressure in the brake pipe.

SUPPLEMENTARY RESERVOIR

When a supplementary reservoir is used in place of the control pipe for the purpose of obtaining graduated release, its connection to the triple valve is made into port *x* as with the control pipe. With this system all the air passing to both the auxiliary reservoir and supplementary reservoir in charging is taken from the brake pipe through feed groove *i* and ports *y*, *j*, and *u*, into the auxiliary reservoir, thence down through ports *k* and *x* into the supplementary reservoir, which is charged to maximum auxiliary reservoir pressure.

This passage connecting the two reservoirs is open only when the triple valve is in release position; therefore, supplementary-reservoir air is retained at its maximum pressure while the brakes are applied. When the piston, slide valve, and graduating valve are moved to release position (Fig. 42), again establishing communication between the two reservoirs through ports *x* and *k*, the back flow of air from the supplementary reservoir to the auxiliary reservoir moves the piston and graduating valve to "graduated-release-lap" position (Fig. 45), unless the brake-pipe pressure is raised more rapidly than that in the auxiliary reservoir. Consequently the graduated release

is available under control of the operator substantially the same as when the control pipe is employed.

EMERGENCY

When the brake-pipe pressure is reduced more rapidly than the air can flow from the auxiliary reservoir to the brake cylinder through service-application port *z*, the piston compresses

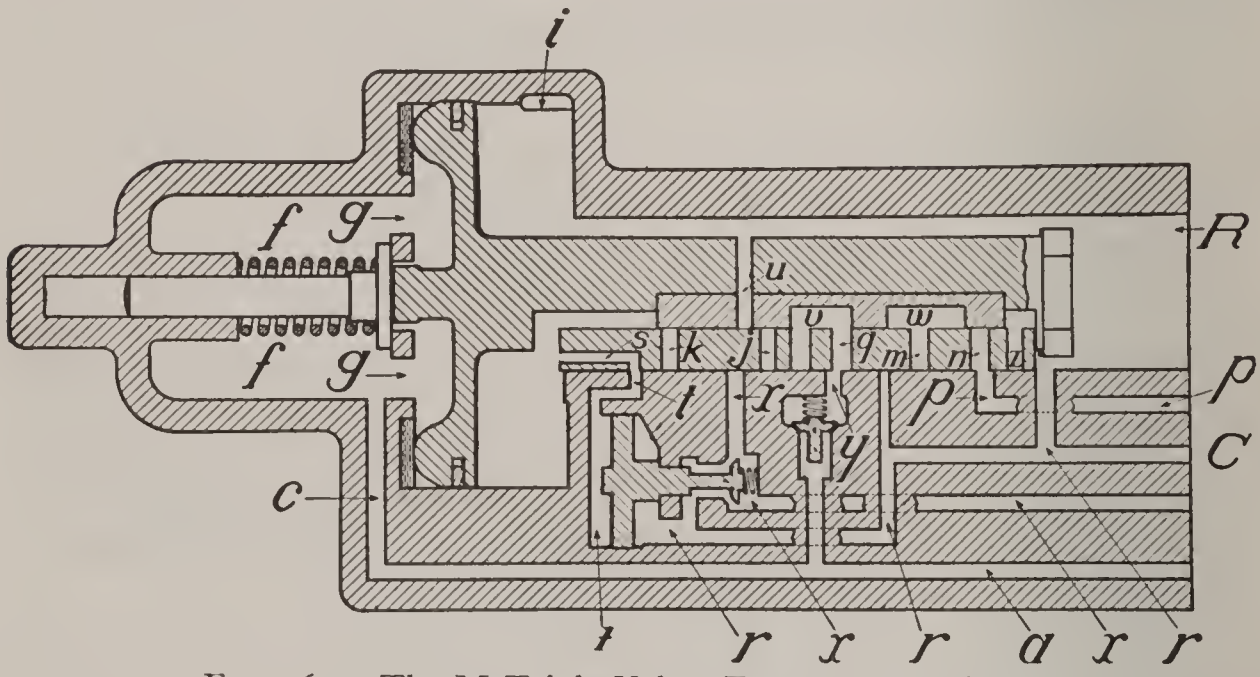


FIG. 46. — The M Triple Valve, Emergency Position.

the graduating spring and moves through its extreme traverse to the left to emergency position (Fig. 46). Air from the auxiliary reservoir then flows past the end of the slide valve through port *r* into the brake cylinder. At the same time auxiliary-reservoir air flows through ports *s* and *t*, forces the "By-Pass Piston" to the right, opening the "By-Pass Valve." Air from the control pipe then flows through port *x*, *x*, past the by-pass valve through ports *r*, *r* into the brake cylinder. When the auxiliary-reservoir and brake-cylinder pressure becomes equal,

air continues to flow from the control pipe and enters both the brake cylinder and auxiliary reservoir through port *r*. When the brake-cylinder and auxiliary-reservoir pressure nearly equals that of the control pipe, the by-pass piston and by-pass valve are returned to their normal position by the valve spring, cutting off further communication from the control pipe and the auxiliary reservoir and brake cylinder. This action of the triple gives a much higher brake-cylinder pressure in emergency than is possible with standard quick-action triple valves.

The action of the triple valve in an emergency application is identical when installed with either a control pipe or a supplementary reservoir.

The R–2 triple valve is of the pipeless type and designed for trains of five or more cars, but is also used on trains consisting of less than five cars when the conditions of service are such that the number of cars per train may at times, or in the future, be increased to more than five cars. It is of the quick-action triple-valve type, and performs the following functions:

First. "Quick Recharge" of the auxiliary reservoir.

Second. "Quick Service" application of the brake.

Third. "Graduated Release" of the brake-cylinder pressure.

It requires the usual brake pipe, auxiliary reservoir, brake cylinder, and exhaust connections, and an additional connection for either a control pipe or a supplementary reservoir. The use of the control pipe makes possible the graduation of the release, also an unlimited number of successive service applications without loss of braking power, such as results with the standard plain and quick-action triple valves. The control-pipe pressure is maintained equal to the maximum brake-pipe

pressure by a feed valve located in the supply pipe from the main reservoir.

When a supplementary reservoir is used in place of the control pipe, graduated release can be obtained, and a number of brake applications made, without seriously reducing the braking power.

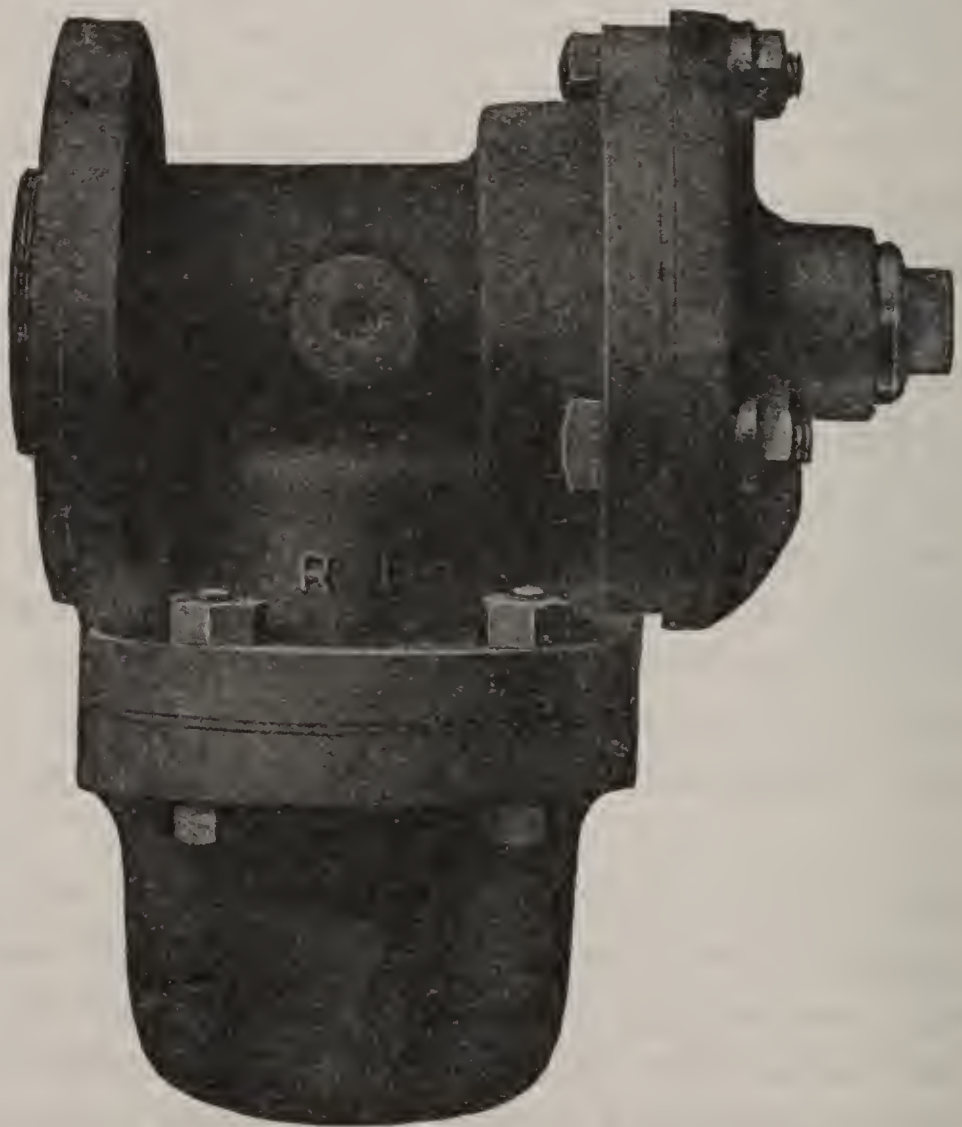


FIG. 47. — The R–1 Triple Valve.

OPERATION OF R-2 TRIPLE VALVE

Charging

Referring to Fig. 48. Air from the brake pipe enters the triple valve at passage *a* and charges the auxiliary reservoir

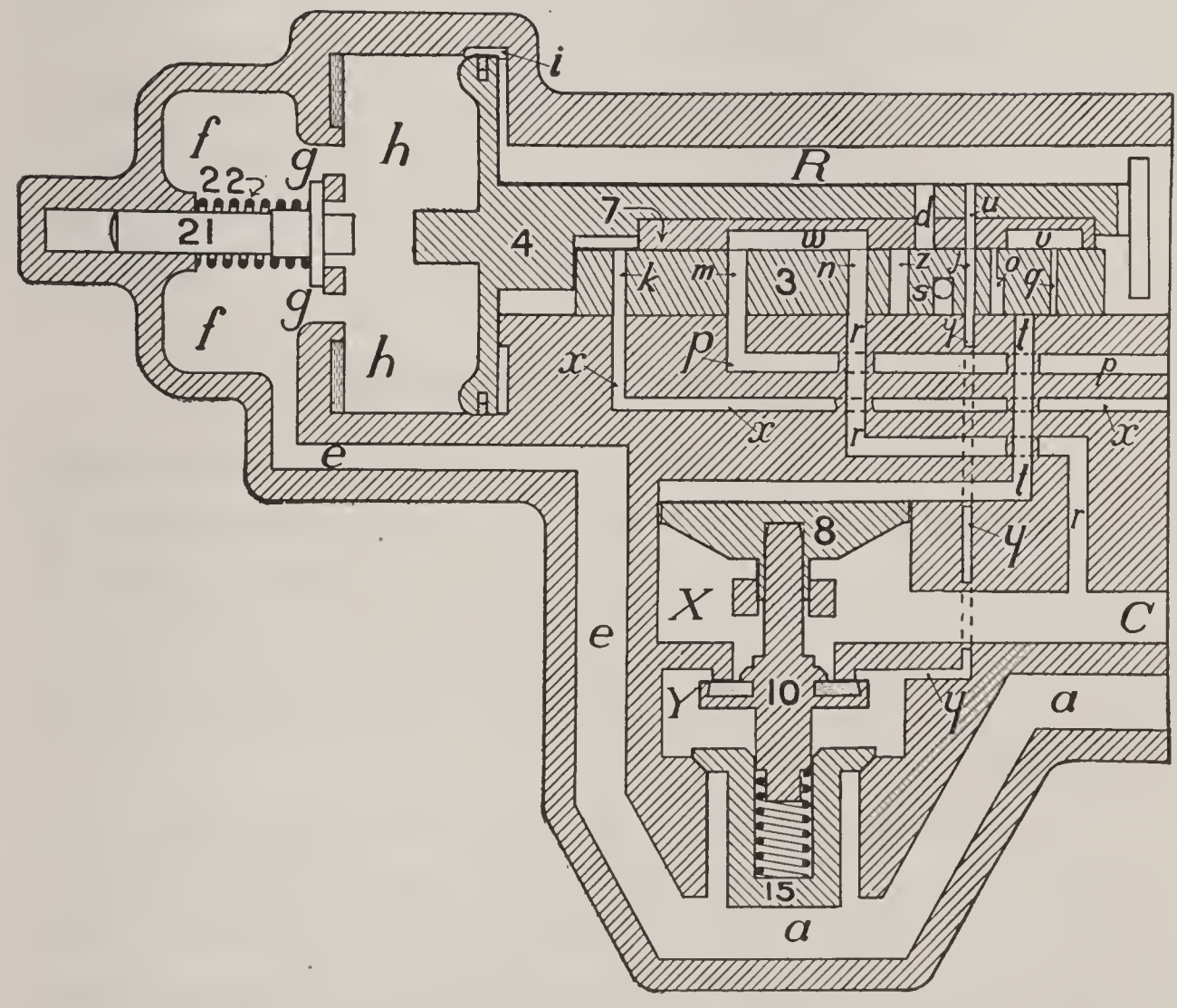


FIG. 48. — The R Triple Valve, Release Position.

through two separate channels. Through passage *a*, *e*, *f*, and *g*, chamber *h*, feed groove *i* and chamber *R* into the auxiliary reservoir; also from passage *a* past the check valve to chamber *Y*, thence through ports *y*, *j*, and *u* into chamber *R* and the

auxiliary reservoir; at the same time air from the control pipe enters the triple valve through passage *x* and flows through port *k* into chamber *R* and the auxiliary reservoir. With these three channels supplying air to the auxiliary reservoir simultaneously, maximum pressure is obtained very quickly.

The rate of charging the auxiliary reservoir through the three channels mentioned is such that a given volume of air can be restored in the auxiliary reservoir in the same interval of time required for the exhaust of an equal amount from the brake cylinder to the atmosphere, thus maintaining an available maximum braking force at all times.

SERVICE APPLICATION

The parts of the triple valve being in the position shown in Fig. 48, a service reduction of brake-pipe pressure moved the piston and slide valves toward the service position, shown in Fig. 49. When making this reduction, the check valve is held to its seat by the spring, preventing any back leakage of auxiliary-reservoir pressure to the brake pipe through this large charging port.

The first movement of the piston and graduating valve closes feed groove *i*, also charging ports *j* and *k* and the exhaust port *m* in the slide valve. During the further movement of the piston to service position, shown in Fig. 49, the closure of the ports mentioned is maintained by the graduating valve. When the slide and graduating valves are in service position, air flows from the auxiliary reservoir through ports *d*, *z*, and *r* to the brake cylinder, and at the same time air in the brake pipe at *a* raises the check valve and flows through ports *y* and *o* into cavity *v*

in the graduating valve, thence through ports *q* and *t* past the loosely fitted emergency piston into chamber *X* and the brake cylinder, thus producing a brake-pipe reduction at the same time that the auxiliary-reservoir pressure is flowing to the brake cylinder through port *Z*.

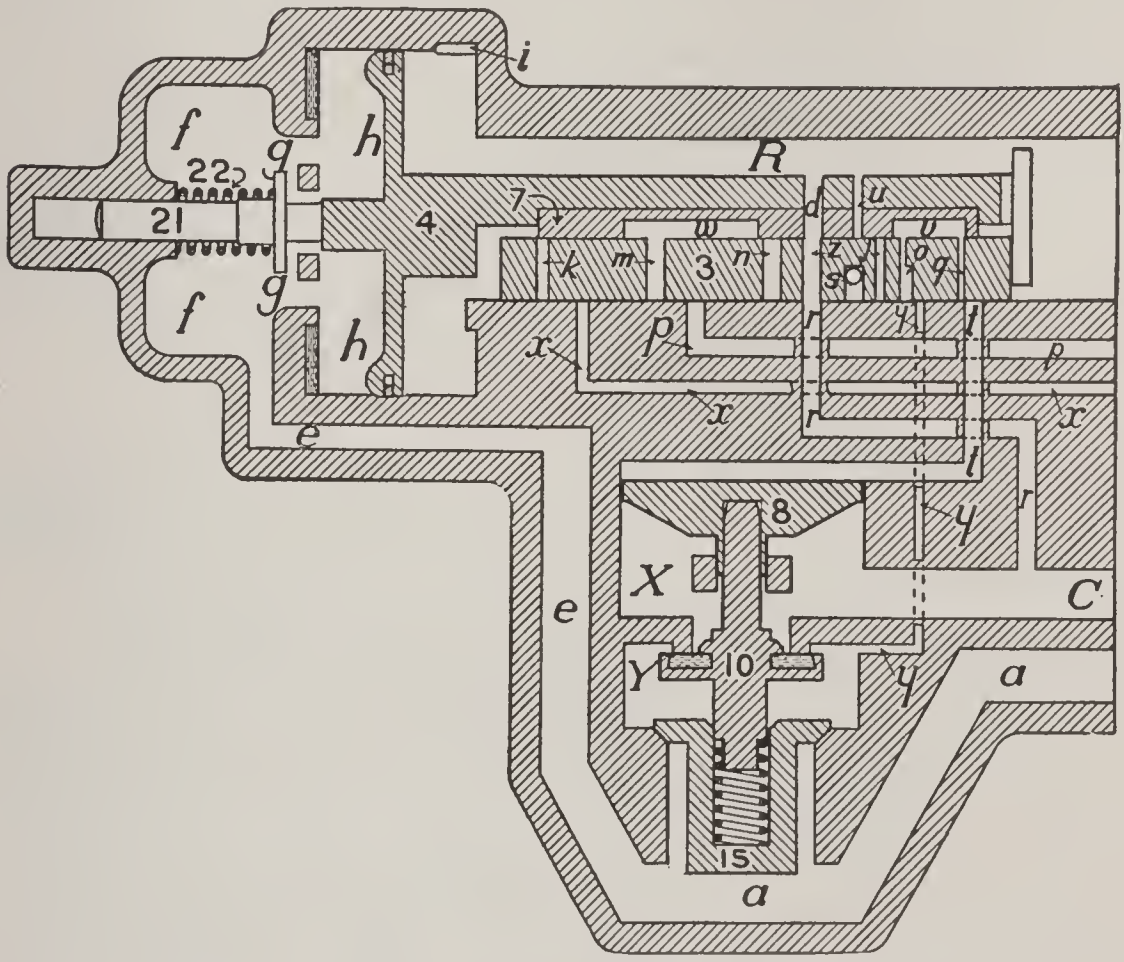


FIG. 49. — The R Triple Valve, Service Position.

The relative capacity of the ports conducting air from the brake pipe and auxiliary reservoir to the brake cylinder is such that the pressure in the auxiliary reservoir will reduce more rapidly than that in the brake pipe, therefore it is impossible for the piston and graduating valve to remain in service position after the brake-pipe reduction to the atmosphere is stopped.

When the auxiliary-reservoir pressure has been reduced to slightly less than that in the brake pipe, the piston moves the graduating valve to the right and closes service port *z* and quick-service port *o*, thus preventing any further flow of air to the brake cylinder until an additional reduction is made in the brake pipe. The piston and slide valves are now in "Service-Lap" position (Fig. 42).

RELEASE

The piston and slide valves being in service-lap position, shown in Fig. 50, raising the brake-pipe pressure above that in the auxiliary reservoir at *R* causes the movement of these

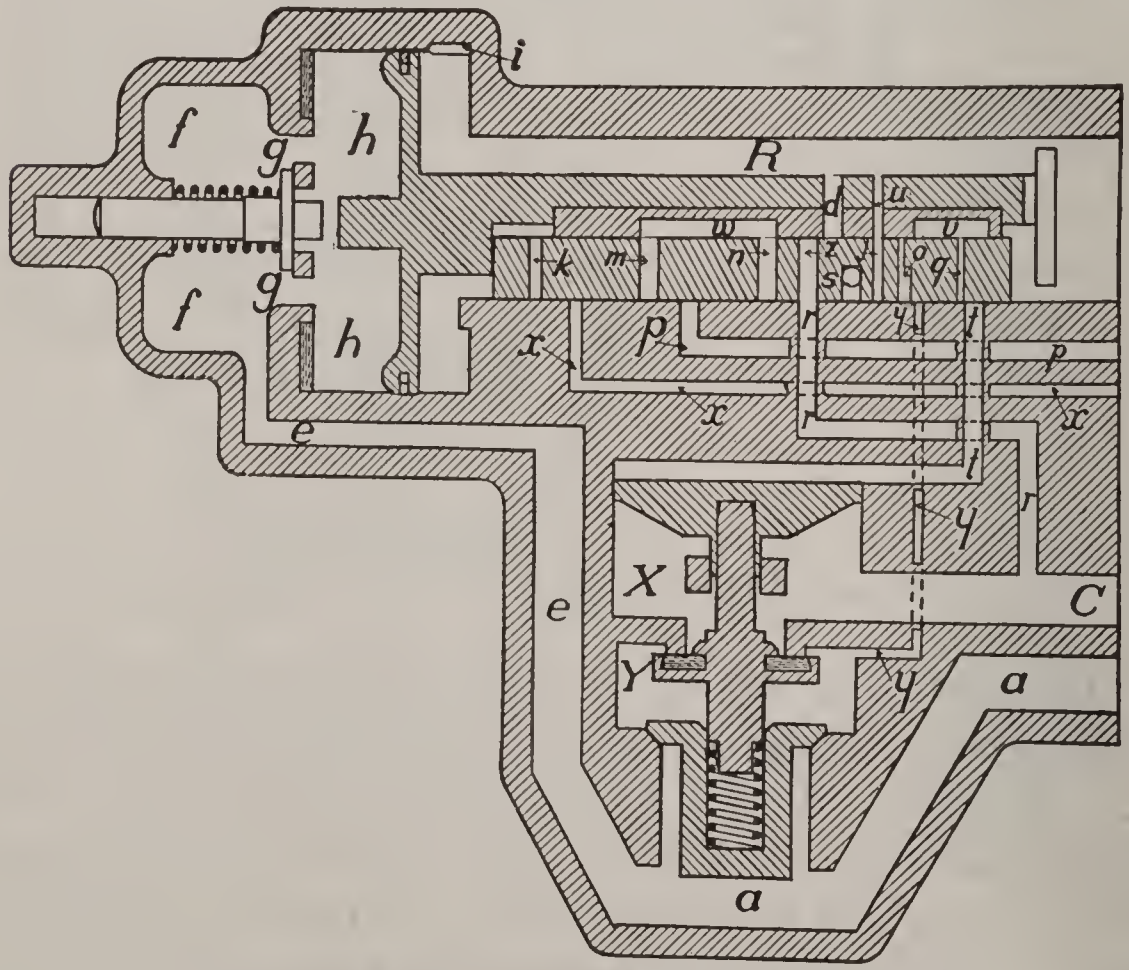


Fig. 50. — The R Triple Valve, Service-Lap Position.

parts to the right to release and charging position (Fig. 48). In this position air from the brake cylinder passes through ports *r* and *n* into cavity *w* in the graduating valve, thence through ports *m* and *p* to the atmosphere. At the same time the auxiliary reservoir is being recharged from the brake pipe through ports *y*, *j*, and *u* and the feed groove *i*; also from the control pipe through port *x* and *k* as previously described. In order to obtain a full and continuous exhaust from the brake cylinder, it is necessary to feed air into the brake pipe continuously until the maximum pressure has been obtained.

GRADUATED RELEASE

If only sufficient air is permitted to flow into the brake pipe to move the piston, slide, and graduating valves to release position (Fig. 48), and the brake valve is then returned to lap, the flow of air from the control pipe through ports *x* and *k* to the auxiliary reservoir will raise the latter pressure slightly above that in the brake pipe and move the piston and graduating valve to the left to "Graduated-Release-Lap" position (Fig. 51), where the graduating valve has closed both the exhaust port *m* from the brake cylinder to the atmosphere, and port *j* and the ports *x* and *k* from the control pipe to the auxiliary reservoir, thus retaining a portion of the pressure in the brake cylinder. This operation of the triple valve is known as the "Graduated Release" and may be repeated until the brake-pipe pressure has been increased to nearly its maximum. The reduction of brake-cylinder pressure during a graduated release depends upon the amount of increase of pressure in the brake pipe.

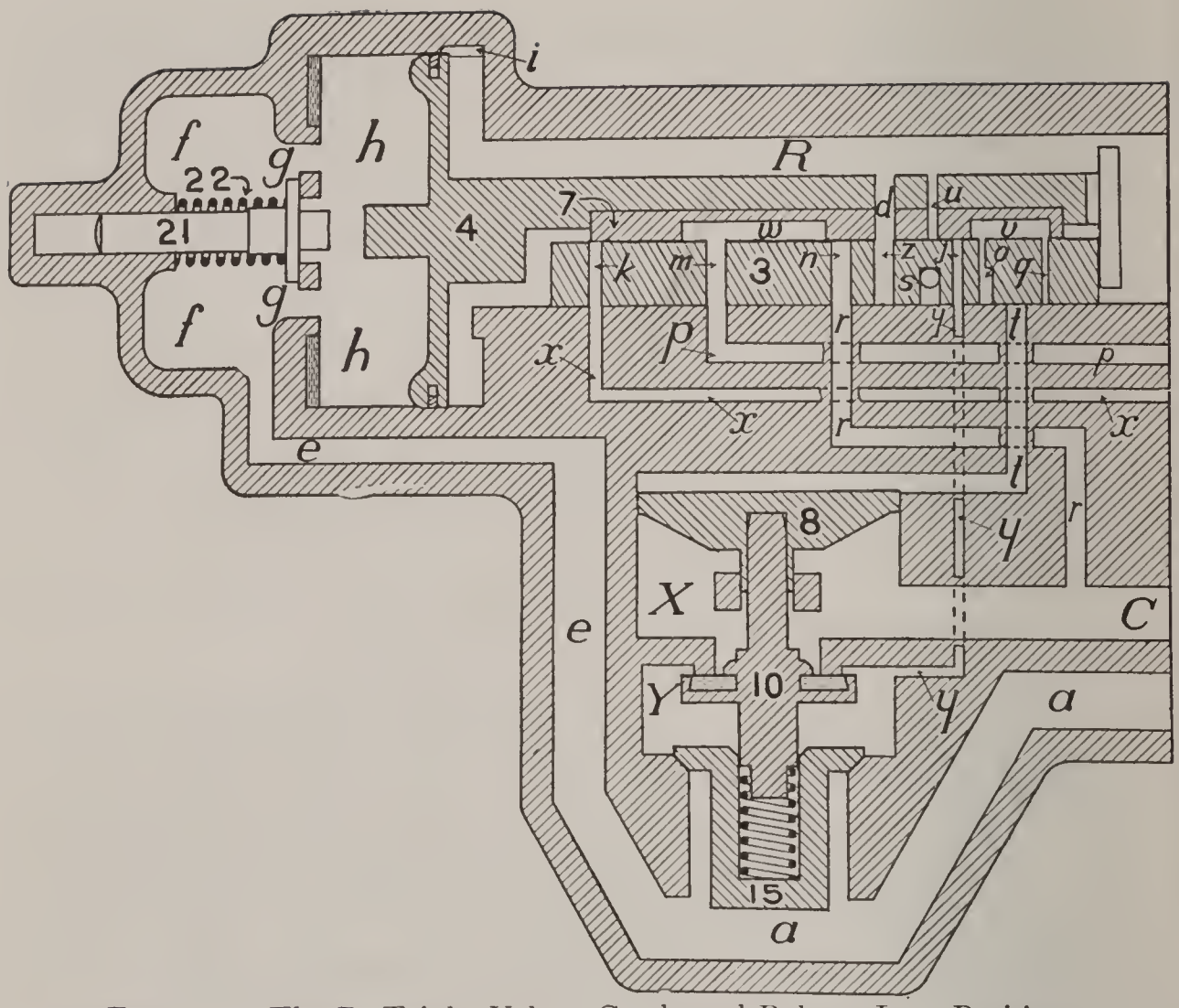


FIG. 51. — The R Triple Valve, Graduated-Release-Lap Position.

SUPPLEMENTARY RESERVOIR

The operation of the R–2 triple valve when installed with the supplementary reservoir in place of the control pipe operates as described under the same heading in the description of the M–2 triple valve.

EMERGENCY APPLICATION

When a reduction of air pressure in the brake pipe reduces it more rapidly than the air can flow from the auxiliary reservoir

to the brake cylinder through service application port *z*, the piston compresses the graduating spring and moves through its extreme traverse to the left to emergency position (Fig. 52). In this position air from the auxiliary reservoir flows through

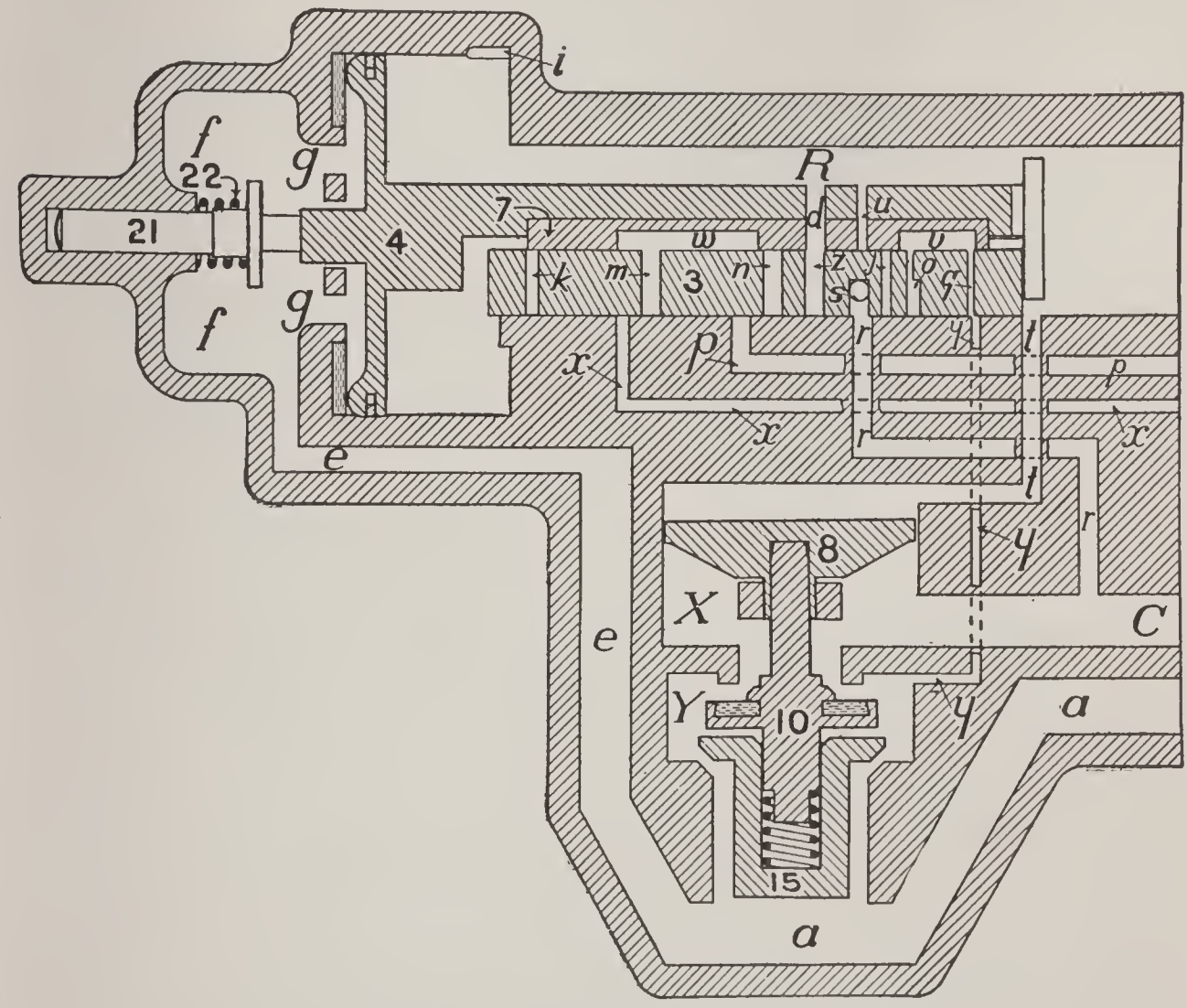


FIG. 52. — The R Triple Valve, Emergency Position.

port *t* to the top of the emergency piston, forcing it downward and unseating the emergency valve. Brake-pipe pressure in passage *a* then raises the check valve, passing through chamber *Y* past the emergency valve into chamber *X* and the brake cylinder. At the same time air from the auxiliary reservoir flows

to the brake cylinder through tail port *x* and port *r* until the pressures in the auxiliary reservoir and brake cylinder are equal. This action, it will be noted, is identical with that of the standard quick-action triple valves and accomplishes the same results.

CHRISTENSEN AUTOMATIC AIR BRAKE

Instructions for Operation

General Instructions. — The engineer or motorman should familiarize himself with the air-brake equipment so that he may obtain a full advantage of the most efficient operation. He should discard the idea that the air brake is difficult and intricate to understand in its details.

Following is a summary of main points for guidance:

First. To start compressor, close the canopy switch. This will automatically close the governor so that current will pass from trolley to ground, through motor operating the compressor.

Second. Should the compressor not start under this condition, the fuse in circuit may be blown. Replace by another fuse of the same rating specified for that circuit. Providing the fuse is in order an open circuit in motor of compressor may present itself. If unable to locate the trouble yourself, a report should be made to the person in charge so that repairs can be made promptly.

Third. While the compressor is charging the main reservoir, one of the engineer's valves should be in lap position; the other in release or running position — also both stops are closed. If the valve is one with automatic train-pipe feed, the

black hand will stop at about 70 pounds pressure, while the red hand of gauge will register at about 90 pounds, usually at which time the governor will open circuit of motor, stopping compressor. Providing the governor is out of order, a much higher pressure will be attained, when the motor circuit should be cut out by hand, by opening circuit switch.

Fourth. All stop-cocks in train must be open, except those at extreme ends of train. When open, the handles stand crosswise to the pipe. When closed, the handle is parallel with pipe.

Fifth. When cutting out governor, close the $\frac{1}{4}$-inch stop-cock so that "T" handle stands crosswise with pipe, then move plunger of governor so as to make a contact, when compressor can be started, throwing out circuit switch when desirous of stopping same so as to keep the pressure within the desired limits.

Sixth. Service Application. — The service applications are alike in both plain and quick-acting triple valves, and are effected by making a reduction in train-pipe pressure of five or six pounds, then moving the engineer's handle slowly back to lap, when reduction has been made. Providing a heavier application is desired, make another reduction of two or three pounds pressure in train pipe. This may be repeated until a 20-pound reduction has been made, at which time there is a complete equalization of pressure between the brake cylinder and the auxiliary reservoir. A further reduction in train pipe would be useless.

EMERGENCY APPLICATION WITH PLAIN TRIPLE VALVE

An emergency application with the plain triple valve is effected by making a quick reduction of 18 or 20 pounds pressure in train line. This has the effect of quickly opening communication between the auxiliary reservoir and brake cylinder. A complete equalization takes place as quickly as the port in triple valve will allow.

EMERGENCY APPLICATION WITH THE QUICK-ACTING TRIPLE VALVE

An emergency application with the quick-acting triple valve is effected by making a quick reduction of 10 or 12 pounds pressure in train line. This difference in pressure between the auxiliary reservoir and train line causes the emergency mechanism to be thrown into action, allowing compressed air to be admitted into the brake cylinder, both from train pipe and auxiliary reservoir, thereby applying brakes quickly and with maximum force.

RELEASE

The releasement of the brakes is the same, both with the plain and quick-acting triple valves, and is effected by moving the engineer's valve handle into release and running position, thereby admitting air from the main reservoirs to the train pipe. The air pressure drives the triple valves into release position, allowing air to escape from brake cylinder to atmosphere.

When the handle of the plain automatic engineer's valve

is in release and running positon an unobstructed passage is formed from main reservoir to the train pipe so that pressure may equalize between them under all conditions while handle is in that position. In the automatic engineer's valve with an automatic feed pipe, an unobstructed passage is formed between the main reservoir and train pipe when handle is in release and running position. But this passage is closed automatically as soon as the maximum train-pipe pressure (70 pounds) is reached.

Under ordinary conditions all of brakes in train will readily release by the simple movement of engineer's valve handle into release and running position, but, under special conditions, it might be necessary in order to release the brakes to introduce into the train pipe an excess pressure, above the specified pressure of 70 pounds. This is accomplished by pressing down lightly on the knob of the stem, which forces the feed valve open, thereby introducing higher pressure than the specified train-pipe line pressure. A complete equalization of pressure between the main reservoir and train-pipe line may be detected in this manner.

To cut out the brake of any given car — providing the brake on any one of the cars constituting the train is out of order or adjustment so as to be ineffective — close the stop-cock nearest triple valve; open the drain-cock in auxiliary reservoir; thus letting all the pressure out in the system of that car. As soon as the triple valve commences to exhaust, close the stop-cock in triple valve as the pipe will then be released and out of action.

MAKING UP A TRAIN

In making up a train, care should be taken to have the stop-cocks on all the communicating cars open; also, to have the stop-cocks in the triple-valve pipe open, but of course the stop-cocks on the front and rear end of the train must be closed. Remember to hang the hose coupling, on the front and rear end, in the dummy coupling to prevent dirt and dust from entering the train pipe. Before the train is put in service, the brakes should be fully tried, both for applications and release. In parting a train the uncoupling of the hose should always be done by hand.

CONDUCTOR'S VALVE

The conductor's valve placed on each car and in direct connection with the train pipe is arranged with a cord within easy reach of the conductor, so that, in cases of emergency, he may reduce the train-pipe pressure and thereby apply the brakes by opening this valve. As soon as the engineer notices the setting of the brakes in this manner, he should immediately shut off the current and put his valve in lap position, otherwise, with a self-closing conductor's valve, the brake may again release. Where a hand-closing stop-cock is used for the conductor's valve, always close it after this kind of an application has been made, otherwise the brakes cannot be released.

CATECHISM ON AUTOMATIC AIR BRAKE

Q. When operating an air brake, what power is used?

A. *Compressed air.*

Q. By what means is the compressed air obtained?

A. *By an air compressor.*

Q. What causes brake application?

A. *By air being admitted to the brake cylinders, forcing a piston out which by means of a suitable system of connecting rods and levers pulls the brake shoes against the wheel.*

Q. How are the brakes released?

A. *The air in brake cylinder is allowed to escape to atmosphere. A spring on the inner side of brake cylinder presses against the piston, forcing same to its normal position, at the same time the brake release spring tends to force shoes away from the wheel.*

Q. What is the present type of air brakes?

A. *Quick-action automatic air brake.*

Q. Why are they called automatic air brakes?

A. *For this reason: no matter what causes a reduction in the brake-pipe pressure, the brakes are applied automatically.*

Q. What parts compose an automatic air-brake equipment?

A. *An air compressor, pump governor, main reservoirs, auxiliaries, feed valve, safety valve, 2 brake valves, 2 air gauges, triple valve, conductor's valve, 2 air strainers, 2 pair of hose and coupling, 6 cut-out cocks, 1 double cut-out cock, 1 air strainer with check valve and 1 branch-pipe air strainer.*

Q. Where are brake valves and air gauges located?

A. *In the motorman's cab, at each end of the car.*

Q. What parts are installed on the trailer car with a quick-action brake?

A. *Auxiliary reservoir, brake cylinder, triple valve, controller and brake-pipe line, conductor's valve, 4 cut-out cocks, 2 pairs of hose and couplings, 1 double cut-out cock, air strainer with check valve, and 1 branch air-pipe strainer.*

Q. What differences, if any, are there between the auxiliary reservoirs, triple valves, and brake cylinders used in motor cars to those installed in a trailer car?

A. *None.*

Q. Where is the air stored with the automatic system for brake application?

A. *In the auxiliary reservoir, under each car.*

Q. What method is pursued to apply an automatic air brake?

A. *By making a reduction in the brake-pipe pressure, which causes the triple piston to move, allowing air to flow from the auxiliary reservoir to brake cylinder.*

AIR COMPRESSOR

Q. Where and how are air compressors installed?

A. *The compressor is placed in a cradle suspended from the sills of the car.*

Q. In which direction does the compressor rotate?

A. *The shaft always turns so that the compression part of stroke is on the upper half or revolution, or the compressor rota-*

tion is the same as the hands of a clock, when viewing the compressor at gear side.

Q. What method is used for pump lubrication?

A. *The crank case is filled with oil up to a point determined by the oil fitting on the side of crank case. When the level of the oil becomes visible in this fitting the oil level is correct.*

Q. How are the parts of a pump lubricated?

A. *By the connecting rod heads driving the oil over the inside of crank case, and such part of cylinders that are exposed. By this means all crank-shaft bearings as well as cylinders and wrist pins are properly lubricated.*

Q. How often should the oil be replenished?

A. *Once a week.*

Q. What length of time should elapse before the suction box should be cleaned?

A. *Once or twice a month should suffice.*

Q. How is the suction box cleaned?

A. *The outer perforated plate should be removed and the pulled curled hair taken out and thoroughly cleaned by beating in a bag, or by compressed air or other efficient means. It is then replaced and outer perforated plates replaced in position.*

Q. At what pressure is the governor set to start the compressor?

A. *They are set for varied pressures, usually* 105 *pounds.*

MAIN RESERVOIRS

Q. Where does the air flow to from the compressor?

A. *To the main reservoirs.*

Q. Where are the main reservoirs usually located?

A. *Under each motor car.*

Q. What pressure is usually carried in main reservoirs?

A. 120 *pounds, maximum, and* 105 *pounds minimum.*

Q. How often should a main reservoir be drained?

A. *Daily.*

Q. Where does the air flow to from main reservoir?

A. *Through the feed valves to control pipe and thence to operating valve.*

Q. What duty does a safety valve perform?

A. *It prevents overcharging of the brake system in case the electric-pump governor fails.*

SLIDE-VALVE FEED VALVE

Q. Where does the air flow to from the main reservoir?

A. *To the slide-valve feed valve.*

Q. What is a slide-valve feed valve?

A. *It is a device in the pipe from main reservoir to the control pipe. This device automatically reduces the pressure for the control pipe so as to allow a constant pressure.*

Q. What causes a reduction in control-pipe pressure?

A. *Reinstating brake-pipe pressure at release, recharging the auxiliary reservoirs, also maintaintng an air pressure of* 90 *pounds in the system against leakage when brakes are not applied.*

Q. What care should be exercised with a feed valve?

A. *The piston and its slide valve should occasionally be taken out; all dirt and gum removed from them and the chambers. Great care should be exercised not to leave any lint, and to avoid bruising the parts removed. A slight amount of some light lubricating oil should be applied on the face of the slide valve and spring of the latter.*

Q. Should the main reservoir be drained to do this?

A. *No. Close the cut-out cock between the feed valve and main reservoir.*

Q. When properly regulated what can cause the pressure to feed too high in the control pipe?

A. *A leaky slide valve.*

Q. What will prevent the feed valve from opening promptly?

A. *The piston becoming heavily coated with a greasy deposit which retards rapid equalization of the pressure on both sides of the piston.*

Q. What care should be displayed in regulating the feed valves?

A. *Where a number of feed valves are in a train they should be regulated as nearly alike as possible.*

CONTROL PIPE

Q. Where does the air flow to after leaving the feed valve?

A. *Through the control pipe to the operating valve.*

Q. What is the control pipe for?

A. *For conveying to brake valve a supply of air furnished by all main reservoirs of train.*

Q. What are the connections to the control pipe?

A. *From the feed valve to brake valve and to triple valve.*

Q. What is the pressure in control pipe?

A. 90 *pounds.*

Q. Is there any variation in control-pipe pressure during brake application?

A. *No.*

THE ENGINEER'S BRAKE VALVE

Q. Where does the air flow to from the feed valves?

A. *Through control pipe to brake valve.*

Q. What is the pressure from the feed valves to brake valves?

A. 90 *pounds.*

Q. Where does the air flow to from the brake valve?

A. *To the brake-pipe and auxiliary reservoir.*

Q. What is the purpose of a brake valve?

A. *It connects the control pipe to brake pipe; to release the brakes, charge the system and maintain a pressure. To connect the brake pipe through suitable passages to atmosphere, to apply the brakes, to break all connection between the control and brake-pipe line or atmosphere, and to hold the brakes applied.*

Q. On what position is there a communication from control pipe to brake pipe?

A. *In running position.*

Q. In this position, how should the control and brake-pipe pressure stand?

A. *Equal.*

Q. What is the running position to be used for?

A. *For recharging the brake pipe and auxiliary reservoir and prevent brake-pipe leakage from setting the brakes.*

Q. What is the next position of the brake valve?

A. *Lap position; all parts closed.*

Q. When is it used?

A. *When holding the brakes on after an application, or when graduating the release, or when they have been applied by opening a conductor's valve.*

Q. How should the brake-valve handle be turned to lap?

A. *Slowly, after making a brake-pipe reduction so as to cut off the exhaust gradually, that the lead brakes will not be released by the air surging forward quickly, when going to release position to graduate the release.*

Q. Why should it be returned quickly when graduating the release?

A. *Because the longer the brake-valve handle is in the release position, the lower the brake-cylinder pressure will reduce.*

Q. What is the next position, and its use?

A. *Service application, and is used for all ordinary positions.*

Q. How many service application notches has a brake valve?

A. *2 service and intermediate.*

Q. When should they be used?

A. *With a 6-car train the brake-valve handle can be moved to the second service application opening, but with not more than 3 or 4 cars the first or intermediate notch should be used.*

Q. When a three or four car train is being operated, why not use the service notch?

A. *Owing to the comparatively short brake pipe, the reduction of brake-pipe pressure would be sufficiently rapid to cause quick action, resulting in an emergency application of all brakes, when only a partial service application was intended.*

Q. What is the next position?

A. *Emergency, or quick action. In this position a large direct opening is made from the brake pipe to atmosphere.*

Q. When is this precaution to be used?

A. *Only in case of emergency. The handle to be held in this position until all danger is passed.*

BRAKE PIPE

Q. What is the brake pipe?

A. *It is the connection between the brake valve and triple valves, auxiliary reservoir and brake cylinders.*

Q. What difference in pressure between the control and brake pipe takes place when an application is made?

A. *When the brake-valve handle is in full release, there is no difference. When making application of the brakes, the brake-pipe pressure is lower than the control pipe; an amount dependent on what brake-pipe reduction is made by the motormen.*

Q. What devices are placed in the connection from the brake pipe to the triple valve?

A. *The double cut-out cock and branch-pipe air strainer.*

Q. What is the double cut-out cock?

A. *It is a cock having two entirely separate passages through it; one tapped at each end for a 1-inch pipe — the other for a*

$\frac{3}{8}$-inch pipe. The large one is for the branch pipe for the brake pipe to the triple valve. The smaller one is for the branch pipe from the control pipe to the triple valve. The turning of the double cut-out cock closes the communication from both the brake and control pipes.

Q. Why is it necessary to close both the brake and control pipe from the triple valve at the same time?

A. *It makes it impossible, providing anything should happen to the brake cylinder and reservoir and triple valve, to cut them out from one of these pipes and not from the other, which might readily occur, providing each individual pipe had a separate cut-out cock.*

Q. When should the double cut-out cock be closed?

A. *Only when the brake apparatus becomes defective in that individual car and necessitates the cutting out of that unit.*

Q. What is the branch-pipe strainer used for?

A. *To prevent dirt and scale from entering the triple valve, possibly rendering it inactive.*

Q. How are connections made between cars?

A. *By hose coupling.*

Q. What is it necessary to do when coupling or uncoupling hose connections between cars?

A. *To uncouple, it is first necessary to close the cocks of that pipe line on both cars before attempting to uncouple the hose. In coupling see that the hose couplings are properly connected before opening the angle cocks.*

Q. When making up trains, what should be done with the hose at the extreme end of trains?

A. *All hose should be fastened up to the dummy coupler devices.*

TRIPLE VALVE

Q. To what is a brake pipe connected under car?

A. *To the triple valve.*

Q. Why is it called the triple valve?

A. *Because it performs three functions:*

(1) *To charge the auxiliary reservoir.*
(2) *To apply the brakes.*
(3) *To release the brakes.*

GENERAL OPERATION

Q. How should brakes be tested in preparing a train for service?

A. *First, see that hose cut-out cocks are closed at both ends of train and those between cars are open. Next, see that all brake valves are lapped with the exception of the units to be operated, and this must be in release position. Start compressors, charge the brake pipe and air reservoir, allowing the compressor to operate until the governor cuts it out. Motorman will now apply the brakes by allowing a* 10*-pound reduction, placing the brake-valve handle on lap. Now see if all pistons in train have moved out such a distance as to indicate that the brakes are all applied in all cars of train. The brakes can now be released from the last car at end of train. See that all brake cylinders are fully released and brake shoes are free from the wheels.*

Q. What reduction in pressure is necessary for a service application?

A. 18 *to* 20 *pounds pressure.*

Q. How many applications should be made in making an ordinary service stop?

A. *As a general rule, one.*

Q. What is the meaning of an application?

A. *From the time the brakes are applied until fully released. No matter how many reductions or graduated releases. Providing a full release has been made and a reapplication has been executed, this would be termed as a second application.*

Q. How is an ordinary service stop made?

A. *By making an 18 or 20 pound reduction, obtaining a full cylinder pressure at once, gradually reducing same as speed of train decreases.*

Q. Should this method always be followed?

A. *No, if the train is running slow it is not necessary to have a full pressure in brake cylinder.*

Q. Why is it necessary that the pressure in brake cylinder be graduated as the speed of train decreases?

A. *The friction between the brake shoes and wheels is less for high speed than for low speed, having the same pressure in both cases. By making graduated releases the skidding of wheels is overcome.*

Q. To make a complete release of brakes, how should the brake valves be handled?

A. *It should be moved to the release position and allowed to remain there.*

Q. If brakes release after a service application, where should the cause be looked for?

A. *Examine brake valves in train until trouble is located.*

Q. In case of emergency, when it is essential to stop the train in the shortest distance possible, how should the brake valve be operated?

A. *The handle should be thrown to the full emergency and left there until the train has come to a full stop, or all danger is past.*

Q. If the motorman has the brake partially applied with a service application, should he be suddenly flagged, what should he do?

A. *Put the valve handle in the emergency position and leave it there until stopped.*

Q. In case of emergency, should a motorman reverse his motor?

A. *Yes, but only as a last resort to prevent an accident. When using a multiple unit train, use the first position, or switching position.*

Q. In case of an accident, how should the conductor's valve be handled?

A. *It should be pulled wide open and allowed to remain, or be held in that position until the train stops. Before leaving valve see that it is properly closed.*

Q. Can the brakes be released from the conductor's valve?

A. *No. It must be remembered, to release the brakes, it is necessary to either put air into the brake pipe or take it out of the auxiliary reservoir.*

Q. Should the brakes apply suddenly without the aid of the motorman, what would be the cause?

A. *Either a burst hose, burst brake pipe, or train breaking in two.*

TROUBLES ON THE ROAD AND HOW TO OVERCOME THE SAME

In case of a motor dropping, by the aid of a piece of rope it may be secured after raising motor to proceed to car house. In raising the motor by its own power, the reverse switch is set for certain directions, viz., first, when the motor is at rear end of car in that direction, the motor on head end of car must be cut out, and the reverse switch thrown for forward direction. When applying power to raise dropped motor, only the first position of controller should be used. Second, when the motor is on the end of car from which it is being operated, the rear motor must be cut out, and the reverse switch thrown for backward motion of car. Great care should be exercised, in both of the above-mentioned cases, not to leave power on after motor has been raised to the proper height, and blocking same secure.

With a rheostat car, in case of it coming to a standstill, there are but a few connections that can be examined in trying to locate the trouble; however, first of all, see that your overhead switch has contact, and then try your reverse, and be sure that it is fully reversed to give a thorough contact. A great many cars have had to be pushed or towed to the depot on account of this trouble. When trying to locate this trouble, examine your fuse box and see that the fuse is not blown out; see that the thumbscrews are tightly secured on the fuse, and while you are there try the fuse-box leads and lightning-arrester leads, to see that they are not disconnected. Try the lamp circuit to see if the lights can be lit, and see whether the supply wire fastened to the trolley base is burned or broken off. If that wire is found all right the lights ought to burn,

unless the car is on a dead rail, or the rails are covered with sand and dirt, and the motor ground wire has been broken, as the light circuit depends upon a ground before it will burn; also the motor must have a ground before it can be operated. Also see if the supply wire that leads to the rheostat is connected, and then see if the contact shoe is on the rheostat arm; also try the end wire on the rheostat. The end wire is the one on the inside, while the loop wire is the outer one. If the end wire on the rheostat was disconnected the motors would not take the power until the contact shoe touched the loop segment, or if the field-end connection at the motors were either burned off or disconnected the result would be the same, and the car would not start until the power was brought to the loop connection.

After having made a careful examination of the rheostatic connections, then raise the trap and try the motor connections, and if you do not find any of them loose give them a little pull; or it may be that one of them is burned off, and if so, you may connect temporarily with a piece of wire. At any time, when making a temporary connection with a piece of wire, be sure and clear it off of the motor shell, so that it will not ground and burn off again, and in case of your having to use small wire, do not force your car too much, for you may burn it off again. A small water pipe will not carry as much water as a larger one, and it is the same with wire — the smaller the wire the less current it will carry. After having examined the motor connections, including the main ground wire, and having found them all right, there is but little more that could be done on the road in trying to locate the trouble. It might be a short or broken carbon, or perhaps the carbon may be stuck

in the holder; but you can easily determine this by opening the motor cover and pulling the brush hammers back and inspecting the carbons. After having done this, and you fail to locate the trouble, your only resort is to have the car towed home. If you ever have occasion to examine the carbons, do not fail to put the brush hammers down again. When you have a car equipped with two motors and controlled by the rheostatic method of control, sometimes you may find that only one of the motors is working. Upon investigation you will find that in a great many cases the reverse has not been fully thrown. You should always make sure and throw the reverse over in full; if not, only one motor will work, besides there is the danger of burning off the contact tips on the reverse switch, and then the car would have to be changed off or taken out of service, and when the shop man would take down the reverse switch cover he could plainly see that it was caused by carelessness on the part of the motorman.

When you have occasion to push or tow a car equipped with two motors and controlled by a T. H. rheostat, be sure and have it reversed in the same direction that you are moving, because if you do not, and when you attain a little speed, one motor will act as a dynamo and drive the other motor in a reverse direction as a motor, and you will hardly be able to move it unless you couple it to two or three cars.

If at any time you have a collision with another car or a wagon, and the controlling stand is bent so badly that you cannot either apply your power or reverse your car, you can run your car with the overhead switch, and to reverse the direction cross-connect the brush leads in both motors, if a double-motor car. Also in connection with cars operated by the

rheostatic method of control, it may be well to remind you that you should not run through water at a high rate of speed, or with the power on, as water splashing up underneath and on the rheostat is liable to cause the current to jump from the rheostat spindle to the frame, and from there to and through the conductors laid in the frame, and then through the motors, so that when you do shut off the power with the handle in the regular manner, the car would still move. As previously stated, these conductors are insulated from the rheostat frame, but in course of time the insulation is liable to become imperfect. Of course, as long as the insulation remains perfect there is no danger of this occurring. If you ever have a car that continues to move after you have apparently shut the power off, you should investigate at once. Throw off your overhead switch immediately. Upon investigation you will find that either the rheostat spindle is grounded to the frame, or that the cable has slipped on the drum. This electrical trouble is one that often happens during rain or snow storms. In a case of the kind it is advised that, when you want to make a stop, you should throw off the power, except the first quarter position, and then throw off the overhead switch, leaving your handle still on the first quarter, and then when you want to start up again release your brake and throw on the overhead switch and increase the speed of the car as usual with the controlling handle. The idea of leaving the power on the first quarter and throwing off the overhead switch is that by so doing you are not so liable to make mistakes, and besides, it prevents the arcing between rheostat spindle and rheostat frame, which increases each time you throw off the power with the controlling handle, unless you throw off the overhead switch as well.

In case of trouble with controller cars, you will examine in much the same manner as with cars equipped with the old-style T. H. rheostat. Of course you do not have the rheostat connections and contact shoe to examine, but you have the controller instead. If your car does not move on the first position and will move on the second position, it will be either that one of the contact fingers has no contact, or that one of the resistance leads is either disconnected, burned, or broken off. If both controllers work the same, it would be in resistance lead R–1 being disconnected or burned off from resistance. Of course it may not be where it is connected to the resistance as it might be in the controller. If it is in the controller, then the car could be operated from the opposite controller, and would start up on the first position. You will readily see by diagram No. 1, Fig. 52*a*, how this would affect the operation of a car.

The long line in the diagram represents the R–1 resistance wire, running from No. 1 controller to No. 2 controller, the entire length of the car. The short line represents the R–1 tap leading to the resistance. If there is a break at any point between A and B, then the car will not start on No. 1 controller until you turn the handle to the second position, but will start up on the first position on No. 2 controller. If there is a break at any point between B and D, or, in fact, anywhere between the R–1 tap and No. 2 controller, the car will not start until the second position on No. 2 controller. If there is a break at any point between C and B, then the car will not start from either controller until put on the second position. If the R–1 tap is burnt off where it is tapped on (marked B), then the car will not start from either controller until put on

the second position, providing all the other resistance wires are in the proper connection.

If all the resistance wires were disconnected on a K controller, the car would not start until the third position; or if R–3 wire was disconnected, it would not start until the third position, because R–3 is the negative wire leading from the resistance. If all the wires were disconnected from one of the controllers, it would not prevent operating the car by the other controller, providing that the wires were not touching each other on the other end, meaning the end that was disconnected.

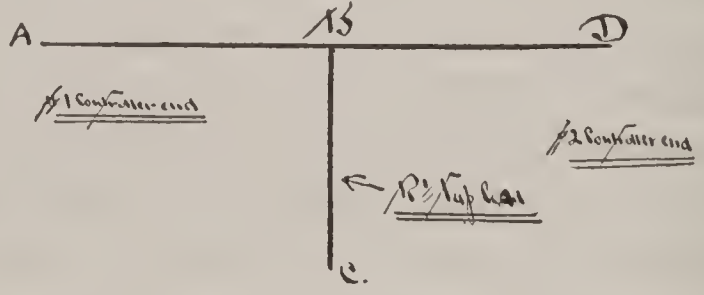


FIG. 52*a*.

If you have a car and one of the controllers does not give the notches as it should, you should report the defect to the person in charge. You can easily tell when a controller has this defect, because you will not hear the click that it gives when in order. The cause of this is that the cam roller spring is either broken or has become detached, or the rivet going through the cam roller is worn through, or perhaps the cam or star wheel is loose on the spindle. Controllers are automatic in every detail and should check any tendency to carelessness or forgetfulness on the part of a motorman. Controllers are known as series parallel controllers. Usually this method of control differs from the rheostatic method in this way: with the rheostatic method, the motors are connected

permanently in parallel, while with the series parallel method the motors are first temporarily connected in series, the current first passing through one motor and then through the other without division. By this means, together with a slight resistance, the proper starting pressure is applied, and the motors being in series, the same current that starts one flows through and is used again in the other. After the car is started the voltage applied to each motor is increased by throwing both motors in parallel.

The safe running positions on a 7-notch G. E. controller are 3 and 6, and on a 9-notch 4 and 8. Where the shunt resistance is used the loop would be the fourth and seventh position on a 7-point controller, and the fifth and ninth position on a 9-point controller. When running on the shunt position of controller, a portion of the current is shunted from the field circuit, and allows an increase of current to armature circuit, causing an increase of speed, due to the weakening of the field magnetic circuit.

RAILWAY SIGNALS

There are several classes of railway signals for governing train operation:

First. Semaphore type of signals.

Second. Low dwarf signals.

Third. Pot signals.

Semaphore signals are used by railway companies for the purpose of conveying a signal at distance, either for danger or for safety. There are two classes known as (1) home signal, and (2) distant signal. The home signal is designated

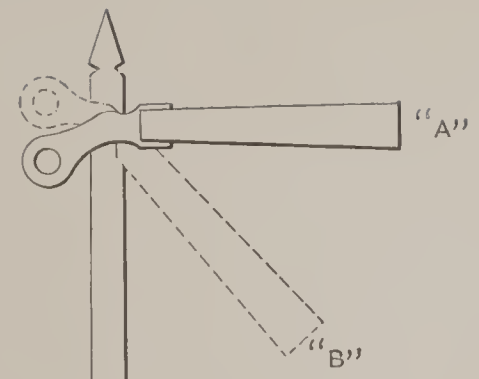
by a blade with square end and painted red; also having on its face a vertical white stripe. The distant signal is designated by a fish-tail blade, and usually painted green or yellow, having a V-shape black stripe on face of blade. These signals are also designated by different colored lights for night. The home signal when set for danger has arm at angle of 90 degrees, or horizontal when displayed for day, and when set for danger at night, a red light is displayed; when set for safety in day, the semaphore arm is dropped to an angle of about 60 degrees, and when at night, a green light is displayed.

The distant signal indicates caution when the arm is at an angle of 90 degrees for day signal, when it displays a yellow light at night. When set for safety the arm is dropped to an angle of about 60 degrees for day, or displays a green light at night. When a distant signal has its arm at an angle of 90 degrees by day and displays a yellow light at night, it indicates that the home signal is set at danger. When the distant signal has its arm at an angle of 60 degrees by day, and displays a green light at night, it indicates that the home signal is also clear, or at safety.

Where there are three semaphore arms located on the same mast, they govern three tracks; usually the arm at the top governs the extreme right-hand track, the next lower or middle arm governs the track to the left of that track, while the lower arm governs the third track, or the track to the extreme left.

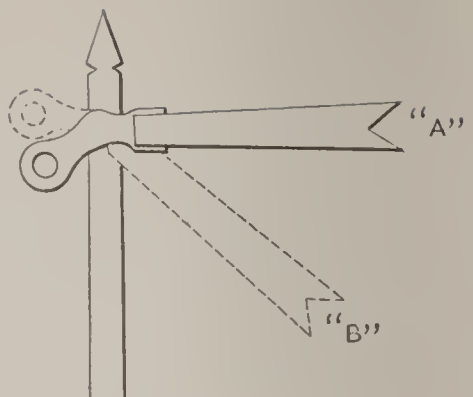
PERMISSIVE SIGNALS

A permissive signal is practically a positive signal, and is of the home signal type. The permissive signal, when set at danger, indicates stop, but after two blasts of the whistle are



HOME SIGNAL
POSITION "A"
DENOTES STOP.
POSITION "B"
DENOTES PROCEED.

DISTANT SIGNAL
POSITION "A"
DENOTES HOME SIGNAL IN STOP POSITION.
POSITION "B"
DENOTES HOME SIGNAL IN CLEAR POSITION.



HOME SIGNAL

DISTANT SIGNAL

sounded it allows the train to enter that block under full control, until the next block is reached, and so on, until the train reaches a positive home signal. This signal is designated by a pointed end on semaphore blade; there is also usually in connection with this a distant signal, which is mounted upon the same mast with the permissive signal, which are operated automatically by movement of train; both signals are set at danger and caution, while entering block; when the train arrives at the next mast, the permissive and caution signal is also set for danger and caution on that mast, but after passing the second mast, the permissive signal on the first mast is set at safety, and so on until train approaches a positive home block. These signals are known as automatic semaphore signals.

DWARF SIGNALS

A dwarf signal is a pot signal, carrying a semaphore arm, and also having lamps. The semaphore arm of this type of signal is recognized by its color by day, and by different colored lenses at night. These are usually red and green discs. By day, when the semaphore arm is at an angle of 90 degrees, the signal is set at danger, and when at an angle of 60 degrees, the signal is set at safety. When displaying red light at night the signal is set at danger, or when displaying a green or yellow light it indicates that the signal is set at caution or safety; this type of signal is installed for yard service, also for cross-over work on main line.

SERIES OF QUESTIONS AND ANSWERS RELATIVE TO THE OPERATION OF ELECTRIC CARS

Q. What is the office of a fuse?

A. *To prevent an overload of current at the motor terminals.*

Q. How does a fuse prevent an overload of current at motor terminals?

A. *By fusing or melting when an overload of current occurs in that circuit.*

Q. What is meant by an overload of current?

A. *An overload of current means that amount of current which exceeds the carrying capacity of the fuse in circuit.*

Q. What are causes producing an overload?

A. *An overload is caused by improper use of controller, such as feeding too fast, or by reversing, also by lightning striking the line, which allows a heavy charge upon the line.*

Q. Why is the fuse made to be the weakest part of the circuit?

A. *So as to rupture the circuit at that point.*

Q. Why is it necessary to rupture the circuit at that point?

A. *So as to protect the equipment.*

Q. At what part of the circuit is the fuse usually placed?

A. *Between the second main motor switch and the lightning arrester or controller.*

Q. Of what material is a fuse usually composed?

A. *A fuse is usually composed of lead, with a certain amount of alloy in its composition.*

Q. How is the carrying capacity of a fuse designated?

A. *By having the number of amperes stamped on one of the copper terminals of the fuse.*

Q. What precaution should be used in inserting a fuse?

A. *When inserting a fuse, the terminals should be thoroughly secured with thumbscrews of binding-post.*

Q. Why is it injurious to run on resistance points?

A. *On account of heating resistance coils.*

Q. Why is resistance used in a motor circuit?

A. *Resistance is placed in circuit with a motor for the purpose of overcoming a rush of current to motor terminals, on starting, which would cause a too sudden movement of armatures.*

Q. How is the resistance sometimes spoken of relative to the motor circuit?

A. *The resistance, in connection with a motor circuit, is sometimes termed exterior resistance.*

Q. What are resistance coils also called?

A. *Rheostat or diverter coils.*

Q. What are resistance coils composed of?

A. *For street railway motors the resistance is generally composed of long strips of iron ribbon. Several years ago resistance coils were composed of German silver wire, but for commercial reasons this has been discarded for either wrought or cast iron.*

Q. How are the resistance coils made up?

A. *Resistance coils are made up in two forms, one of which is known as the panel form, in which the resistance is placed in*

layers, with asbestos between each layer; the other is cylindrical in shape, with asbestos or mica insulation separating the layers of the coil.

Q. Why is asbestos or mica placed between each layer?

A. *To prevent the coils from being short-circuited and to secure the full resistance of the coil. Both of these materials are insulators and are capable of standing a high temperature without deterioration.*

Q. What is meant by short-circuited?

A. *A short circuit means that the current, instead of going through its regular course, is carried to ground through a shorter pathway on account of the lessening of resistance.*

Q. Where is No. 1 motor located relative to end of car?

A. *No. 1 motor is always termed as being the motor nearest the fuse box.*

Q. Where is No. 2 motor located?

A. *Motor 2 is always termed as being the motor farthest from the fuse box.*

Q. How is No. 1 motor cut out in a G. E. controller?

A. *By throwing up the left-hand switch in controller.*

Q. How is No. 2 motor cut out in a G. E. controller?

A. *By throwing up the right-hand switch.*

Q. How is No. 1 motor cut out in a Westinghouse 28–A controller?

A. *By placing the handle of the No. 1 cut-out plug in a vertical position in both controllers. The No. 1 cut-out plug is the bottom one.*

Q. How is No. 2 motor cut out in a Westinghouse 28–A controller?

A. *By placing the handle of the No. 2 cut-out plug in a vertical position in the controller that is being operated at the time. The No. 2 cut-out plug is the top one.*

Q. What precautions are necessary before cutting out a motor?

A. *Always throw off the overhead switch or circuit-breaker. This should also be done when inserting a fuse.*

Q. Why is it injurious to the motors to run the car with the power on and brakes partly set?

A. *Because it heats the armatures and fields and destroys the insulation.*

Q. How does heating destroy the armature and field-coil insulation?

A. *By carbonization.*

Q. What defect is liable to be caused by carbonized insulation of armature or field coils?

A. *A short circuit, or ground, caused by the layers of the coils of wire coming in metallic connection with each other.*

Q. What is the result usually of running the car through water at an excessive rate of speed with the power on?

A. *It is liable to produce short circuits in the motor with armature, field coils or brush-holder yokes, also a possibility of producing short circuits in resistance coils.*

Q. What is meant by controller interlocking device?

A. *A controller interlocking device is a mechanical arrangement whereby the controlling cylinder is prevented from being operated when the reverse handle is in the center; also reverse*

cylinder is prevented from being thrown in either direction when controlling cylinder is placed in circuit or connection.

Q. What systems are equipped with this device?

A. *General Electric and Westinghouse principally.*

Q. Which wiper is the trolley wiper in a G. E. controller?

A. *The one at the top of the wiper board of controller.*

Q. Which wiper is the trolley wiper in a Westinghouse 28–A controller?

A. *The one at the top of the controller.*

Q. Which wiper is the No. 19 in a G. E. controller?

A. *On a G. E. type K,* or *K–1 controller,* the *No.* 19 *wiper is the fifth wiper down from the top. On a type K–2 G. E. controller, the No.* 19 *wiper is the sixth one down from the top of the controller. On a G. E. type K–10, K–11, or K–12, the No.* 19 *wiper is the seventh wiper down from the top of the controller.*

Q. Which is the No. 15 wiper in a G. E. controller?

A. *On a G. E. type K or K–1 controller, the No.* 15 *wiper is the sixth wiper down from the top of the controller.*

On the type K–2, the No. 15 *is the seventh wiper down from the top of the controller.*

On the type K–10, K–11, or K–12, the No. 15 *is the eighth wiper down from the top of the controller.*

Q. Which wiper is the E–1 in a G. E. controller?

A. *On a G. E. type K,* or *K–1, the wipers marked E–1 are the eighth and ninth wipers down from the top of the controller.*

On a K–2, K–10, K–11, or K–12, the wipers marked E–1 are the ninth and tenth down from the top of the controller.

Q. Which is the R–1 wiper in a G. E. controller?

A. *The R–1 wiper is the second wiper down from top of controller. This applies to all types of G. E. controllers. The R–2, R–3, R–4, and R–5 wipers follow in numerical order.*

Q. What would be the result if a blow-out magnet coil in a controller became grounded?

A. *A grounded blow-out magnet coil in either controller will cause fuse in circuit to be blown when both overhead switches or circuit-breakers are thrown on to close the circuit, the controller cylinder being at off or normal position.*

Q. How would you run a car with a grounded blow-out magnet coil?

A. *By disconnecting the positive and negative wires of same and connecting together. This allows the blow-out magnet coil to be entirely out of circuit.*

Q. What is a blow-out magnet coil?

A. *A blow-out magnet coil is composed of a certain number of turns of insulated copper wire or ribbon wound on a core.*

Q. What is the office of a blow-out magnet coil in a controller?

A. *To excite what is known as the pole-piece for the purpose of producing magnetic lines of force, so as to break the arc when throwing the controller to the off position.*

Q. Why is it necessary to break the arc?

A. *To protect the controller from grounds or short circuits, which might be caused by an arc held in the controller.*

Q. What other precautions are taken to minimize the arc at contact wiper point?

A. *Controllers are also equipped with what is known as arc deflectors or barriers, which are placed between each contact wiper to prevent an arc being blown from one contact wiper to another, and on G. E. controllers are attached to the swinging pole-piece of the controller.*

Q. **Why is it injurious to apply the power too abruptly?**

A. *When the power is applied too abruptly it allows a rush of current to motor terminals and is liable to produce short circuits in motors, either on brush-holder yoke or armature circuits. There is also a possibility, with the aforesaid defects, of a current backing up in the controller and causing short circuits or grounds. In regard to mechanical defects liable to result from a too rapid application of the power there is a possibility of stripping the gears and pinions.*

Q. **What is meant by an emergency stop with controller?**

A. *By an emergency stop is meant to make a stop with the controller irrespective of the power in the line or brakes on car.*

Q. **How is the stop made?**

A. *By throwing to off position the overhead switch, then throwing the reverse handle in the opposite direction from which the car is proceeding and then throwing the controller cylinder handle to the last parallel position, allowing it to remain there until the effect is produced.*

GENERAL RULES*

1. *Knowledge of Rules.* Conductors and motormen are required to be familiar with the rules, and with every special order issued. The bulletin board must be examined daily for special orders. Employment by the Company binds the employe to comply with the rules and regulations, and ignorance thereof will not be accepted as an excuse for negligence or omission of duty. If in doubt as to the exact meaning of any rule or special order, application must be made to the proper authority for information and instruction.

In addition to these rules, special orders will be issued from time to time; such orders, when issued by proper authority, whether in conflict with these rules or not, must be obeyed while in force.

1*a*. *Conflicting Rules.* All regulations or orders now in force, contrary to those herein contained, are hereby rescinded.

1*b*. *Discretion.* In all matters not covered by these rules, or special orders, employes are expected to use discretion and judgment.

2. *Report for Duty.* Regular conductors and motormen must report for duty ten minutes before leaving time for their first trip, or if for any good reason unable to so report, must give notice at least ten minutes before such leaving time.

Extra men must report at such time as ordered, or must give notice at least ten minutes before such time. They must not absent themselves after answering roll-call without permission.

2*a*. *Sick-Reports.* Every conductor or motorman reporting sick or excused must report for work within one week thereafter, or send to the Division General Foreman a sufficient reason for longer absence; otherwise his car will be given away and his name will be dropped from the roll. He must also report weekly while away. This rule does not apply in case an employe is excused for a definite time longer than one week.

* The rules in this book printed in *larger type*, are those which have been approved as standard by the Street Railway Association of the State of New York.

Additional rules for the guidance of employes operating surface cars in New York City have been rendered necessary by the existing local conditions. Such rules are printed in *smaller type*.

3. *Personal Appearance.* Conductors and motormen must report for duty clothed in full regulation uniform, and must be clean and neat in appearance.

3*a*. *Badge and Buttons.* The official badge and regulation buttons will be furnished by the Company, and are always to remain its property. They are official tokens that the wearer is in the employ of the Company, and must never be allowed out of the possession of the employe to whom issued. If lost, such loss must be promptly reported at the office.

Badge must be shown and badge number given verbally on the request of a passenger at any time.

4. *Politeness.* Conductors and motormen must treat all passengers with politeness, avoid difficulty, and exercise patience, forbearance, and self-control, under all conditions. They must not make threatening gestures or use loud, uncivil, indecent, or profane language, even under the greatest provocation.

5. *Habits and Personal Conduct.* The following acts are prohibited:

5*a*. Drinking intoxicating liquors of any kind while on duty.

5*b*. Entering any place where the same is sold as a beverage while in uniform or while on duty, except in case of necessity.

5*c*. Constant frequenting of drinking places.

5*d*. Carrying intoxicating drink about the person while on duty.

5*e*. Carrying intoxicating drinks on the Company's premises at any time.

5*f*. Indulging to excess in intoxicating liquors at any time.

5*g*. Gambling in any form, including the laying of bets and playing raffles while upon the premises of the Company.

5*h*. Smoking tobacco while on duty.

5*i*. Smoking tobacco while off duty in any part of the Company's buildings, except in the conductors' or motormen's room.

5*j*. Reading books or newspapers while on duty.

6. *Responsibility.* The motorman is in charge of the car, and is held responsible —

(1) For the safe running of the car.

(2) For the proper operation of the car and its machinery.

(3) For running car according to schedule.

The conductor is in charge of the passengers on the car and is held responsible —

(1) For the safety and convenience of the passengers.

(2) For the collection and proper accounting of fares.

7. *Talking to Motorman.* Motormen while operating cars are permitted to answer questions of superior officers, and to give proper instructions to students only. All other conversation with motormen while car is in motion is forbidden.

8. *Safety.* The safety of passengers is the first consideration. All employes are required to exercise constant care to prevent injury to persons or property, and in all cases of doubt take the safe side.

9. *Warning to Passengers.* Conductors and motormen must, in a polite way, endeavor to keep people from jumping on or off cars while in motion.

If persons attempt to get on or off the car while it is moving, they should be notified politely to wait until the car stops. If the passengers are leaving while another car is approaching from the opposite direction, they should be courteously warned to look out for the car on the other track.

9*a*. In approaching curves conductors must always give the warning, "Hold fast."

10. *Standing on Steps.* Do not permit any one to stand on the steps or buffers. Passengers should be fully inside of car before the signal is given to start.

10*a*. The starting signal should not be given before passengers are fully off the step or running board of car.

11. *Stealing Rides.* Any person caught stealing a ride on a car must never be pushed therefrom while it is in motion.

12.

12*a*. *Ejectments.* No passenger shall be forcibly ejected from a car for any cause whatsoever without order of an Inspector, Starter or official of the Company, unless the conduct of the passenger is dangerous or grossly offensive. In such case the fare must be returned to the passenger, and the ejectment made by the conductor with the assistance of the motorman after the car has been brought to a stop, using only such force as is sufficient to expel the offending passenger, with a reasonable regard for his personal safety. If a police

officer is at hand, the ejectment should be made in his presence, but under no circumstances must the offending passenger be arrested unless ordered by an Inspector or any official of the Company.

13. *Where to Eject.* Any person ejected from a car must be put off at a regular stopping place.

No passenger will be put off at a point where likely to be exposed to danger.

Particular attention must be paid to this rule during bad and inclement weather, late at night, or when a passenger is intoxicated.

14. *Intoxication.* No passenger will be ejected from a car for mere intoxication, unless said passenger becomes dangerous or offensive; such passenger must then be ejected with great care and must be guided until free from probable injury.

15. *Run on Time.* Cars must never be run ahead of schedule time, but must pass time points and leave terminals promptly on time, unless unavoidably delayed.

15*a*. Should the motorman be unavoidably detained, he must not attempt to make up the time by reckless running.

Motormen must not loaf because there are cars close ahead, unless there are no cars close behind.

They will not be held for polling, unless they are running close to leader and leaving the road bare behind.

When a road is not running on schedule time, motormen must divide their headway as the conditions demand.

16. *Steam Railroad Crossings.* Car must be brought to a full stop at a safe distance, approaching steam railroad crossings at grade, and motorman must not proceed until conductor has gone ahead to the center of crossing, looked both ways, and given the COME AHEAD signal. Before starting, the motorman will look back to see that no passengers are getting on or off; and in no case proceed, even after conductor's signal, until he has also examined the crossing and satisfied himself that steams cars are not approaching.

When there is more than one track the conductor must remain in advance of the car until the last track is reached.

After boarding car, conductor will give GO AHEAD signal to notify

motorman that he is aboard. Motorman is forbidden to proceed without this signal.

Where crossing is protected by derail, interlocking plant, or flagmen (employed by the Company) this rule does not apply, special instructions being issued to govern in such cases.

16*a*. *Street Railway Crossings.* Motormen, before crossing the tracks of any intersecting line, must bring the car to a full stop at the near crosswalk, see that the way is clear, and cross such tracks at reduced speed.

When there is a flagman or regularly assigned police officer stationed at crossing, motormen will be governed entirely by his signals, and need not come to a full stop when they have signal to come ahead.

17.

18. *Reporting Defects.* Conductors and motormen will report to Division General Foreman, Inspector, or Starter any defect in car, track, or channel rail, which needs immediate attention.

18*a*. Motormen must report on the car-house sheet at the Depot the condition of every car operated by them during the day.

18*b*. *Defective Channel Rails.* In case a car becomes disabled and it appears that shoes are torn off, the motorman must warn his follower to run carefully over spot where he lost power, or place where he believes the damage occurred. If two cars lose power in succession the follower must be warned, and must not attempt to proceed until the channel rails have been examined.

In all such cases in which there is no Inspector present an emergency wagon must be called.

19. *Disabled Cars.* The motorman or conductor of any disabled car, withdrawn from the main track, must remain with the car until relieved by proper authority.

19*a*. When a car becomes disabled, the passengers must be transferred to the following car if there is room in that car to accommodate them, and the two cars must then be coupled together and the disabled car sent to Depot.

If the following car is crowded, then the passengers must be allowed to remain in the disabled car until there is room in the other car, when they must be transferred to that car.

19*b*. If any part of the car commences to smoke or burn, the passengers must be immediately transferred, as quietly as possible, to another car or to the street without being notified that the car is on fire, when the plow leads must be disconnected and water or sand used to extinguish the fire; water must not be used until the plow leads have been disconnected.

If the fire cannot be extinguished with the material at hand, the Fire Department should be called.

19*c*. In case a car is disabled and is being pushed by follower, the motorman of the live car must not start until he receives signals from the front and rear. Motorman operating disabled car must remain in his place, sounding the gong, and, when necessary to stop, give one tap of the bell, at the same time applying the brakes. In all such cases great care must be used, and the cars must move at slow speed. In no case must a motorman push more than two disabled cars without orders from an Inspector or some person in authority.

19*d*. When the disabled car is being pulled or when two cars are coupled for running, the signal for starting must first be given by the conductor on the rear car and repeated by the conductor on the forward car, each conductor being careful not to give the signal when passengers are boarding or leaving car.

20. *Render Assistance.* In case of accident, however slight, to persons or property, in connection with or near any car, the motorman and conductor in charge of the same will render all assistance necessary and practicable. In no case will they leave injured persons without first having seen that they are cared for.

21.

22.

23. *Reports to be Full and Complete.* A full and complete report of every accident, no matter how trivial, and whether occurring on or near the car, must be made by the conductor. Accidents sometimes considered as not worth reporting are often the most serious, troublesome, and expensive.

The conductor will obtain the name and residence in full of all witnesses on or near the car.

The motorman will assist the conductor in securing the names of witnesses whenever practicable, and will be held responsible for any neglect to render assistance.

In all cases full facts must be obtained and stated in the reports as follows:

The date, exact time, exact place, run and car number, and the direction in which the car was moving, the nature of the accident or collision, and the cause of its occurrence.

The full name and address of the person injured or whose vehicle was in collision (giving the name of both the driver and the owner of the vehicle).

Ascertain the extent of injuries or damage, if any, before leaving the spot.

In case there has been an accident on the car, and the conductors change ahead, the conductor taking car on which the accident happened must secure the names of witnesses, as above.

In case a person is struck by a car after passing around the rear of a passing or standing car, the number of each car must be obtained, and both crews must report the accident.

If an accident is caused by any defect or damaged condition of car, conductor must report the same and its cause.

Accidents to employes will be reported the same as accidents to passengers.

Any trouble or disturbance of a boisterous or quarrelsome character which occurs on a car, or the ejectment of a person from a car, will be reported as an accident.

24. *Report Accidents to Inspectors.* Conductors and motormen will make a verbal report to the first Inspector or official of the Company they meet of any accident, blockade, or mishap of any kind.

25. *Give Information to Proper Persons.* No employe shall, under any circumstances, give any information whatever concerning any accident, delay, blockade, or mishap of any kind to any person except to a properly authorized representative of the Company.

25*a*. Under no circumstances should the names of witnesses in accident cases be given to police officers.

25*b*. Conductors may, however, advise passengers as to the general causes of any blockade and of its probable duration.

26.

26*a*. *Telephone Information.* In case of a serious blockade, where assistance is required to get cars moving, conductor of car first in block must, in the absence of any Inspector or official, telephone at once to Superintendent and give notice and particulars of detention. Expense of telephone message will be refunded upon application at the Division office.

In all cases of collision between cars, and all other cases in which there is serious personal injury, information must be telephoned immediately to the *Report Clerk*, unless there is an Inspector present. If in doubt as to the seriousness of the accident, the information must be telephoned.

27. *Starting Cars after Blockade.* In the event of a blockade of cars from any cause, the cars in such blockade must not all be started at one time, but singly and at such intervals as will not burden the feeder line.

28. *Bell Signals.* From conductor to motorman, to be given on motorman's signal bell:

1 Bell — "Stop at next crossing or station."

2 Bells — "Go ahead."

3 Bells — "Stop immediately."

4 Bells — Given when car is standing — "Back car slowly."

From motorman to conductor, to be given on conductor's signal bell:

1 Bell — "Come ahead."

2 Bells — Danger signal to the conductor.

3 Bells — "Set rear brake."

4 Bells — Signal to Conductor that motorman desires to back the car.

5 —

Whenever a car in service is stopped for any cause except to take on or let off passengers, the motorman will, as soon as he is ready to go forward, give two taps of the gong; after which, if the conductor is ready to proceed, he will give the "Go ahead" signal.

The motorman will answer the signal to stop from conductor by one loud tap of gong; and two loud taps of gong after receiving the signal to go ahead.

If unable to proceed immediately upon receipt of signal, motorman will wait for another "Go ahead" signal before starting the car.

When the car is standing, and motorman desires to back, for any reason, he will give the conductor four bells, but must not move the car until the conductor has answered with four bells to signify — "All is clear behind."

28*a*. When the car has been stopped to take on or let off passengers, motorman must not sound gong to hurry conductor.

28*b*. When backing car power must be applied only to the second notch.

28*c*. Motorman must give one tap on conductor's signal bell for each person boarding car by front platform. These last are to be given slowly to avoid confusion.

29. *Signals before Passing Obstructions near Track.* Before passing any vehicle or obstruction close to the track, where passengers or conductor are liable to be injured while standing on the step of an open car, motorman must give two taps of signal bell as a warning, and must bring his car to a full stop before passing vehicle or obstruction unless he has received GO AHEAD signal from the conductor indicating that all is clear. Great care must be exercised in passing over all excavations, warning workmen of the approach of car by repeatedly sounding gong, car to be under full control. Where excavations are near regular stopping place, car should be run clear thereof before stopped.

30. *Starting.* Motorman must never move car (whether stopped on signal or for any other reason) without signal from conductor, and then only when assured that no one is getting on or off front platform.

Conductor must never give signal to start when passengers are getting on or off.

Conductor must never give signal to back a car unless he is on rear platform and knows track is clear behind the car.

30*a*. Conductor must not put his hands on the bell cord until passengers, if alighting, are on the street and clear of the car; or, if boarding, are upon the body of an open car or on the platform of a box car.

30*b*. Conductor must give the motorman three bells as signal to stop immediately whenever a further backward movement of the car is likely to result in injury to pedestrians or a collision with another car or vehicle.

30*c*. Motorman must start car slowly, so as to avoid jerking. He must turn on power one notch at a time, taking care to strike each notch squarely, and making a distinct stop on each notch, never skipping a notch and never running between notches. Sudden application of power is liable to blow circuit-breakers or fuses. Controller must never be thrown on last point if car does not start from preceding points.

The controller must never be thrown from a higher to a lower notch.

Controller must never be held for any length of time on any point except the first and second running positions.

If necessary to run slower than first running position speed, power must be thrown on and off, and not be taken continuously from a lower notch than that of the first running position.

31. *Danger Signals.* Red lights or flags indicate danger, and when placed on the track, cars must come to a full stop until such signal is removed.

32. *Leaving Car.* When necessary for conductor to leave his car he must notify the motorman to protect passengers and car. Should passengers board car during absence of conductor, motorman will notify conductor of the number and location of such passengers upon his return.

Cars in commission must not be left unprotected; either conductor or motorman always remaining in charge.

33. *Responsibility of Damages.* Employes will be held responsible for any damages caused by their neglect or carelessness or by disobedience of rules.

34. *Transfer Point Meetings.* Motormen and conductors will be held equally responsible for leaving a transfer point so quickly as to prevent the transfer of passengers from an approaching car on a connecting line.

35. *Hearing by Superintendent.* A hearing will be given by the Superintendent to every employe who desires to complain. Reports or suggestions for the betterment of the service will always receive consideration.

36. *Persons Allowed to Ride on Front Platforms:*

(*a*) General Officers, Superintendents, Division General Foreman, Inspectors and Starters.

(*b*) Persons holding written orders signed by the President, Vice-President or General Manager.

(*c*) Employes of the Engineering Departments with badges displayed and wearing soiled clothing may ride on front platform of closed cars, but no more than two will be permitted to so ride at one time, unless cars are on long headway.

(*d*) Employes detailed by the Superintendents or Instruction Department for the purpose of learning to operate the car.

37. *Delay by Teamsters.* In case the driver of any vehicle refuses to pull off track, where it is possible to do so, but persists in standing so as to block track, or in driving so slowly as to keep the car back, conductor must call upon the first policeman to compel such vehicle to turn out. If the officer should refuse to comply, conductor must note his badge number and report same at office.

38. *Disputes.* Motorman must not shout or yell at teams or persons, nor, under any circumstances, use profane or vulgar language. They must not enter into any dispute or altercation with teamsters or other persons.

39. *Newspapers.* Pedlers and newsboys must not be allowed to sell merchandise or papers on cars.

40. *Advertising Racks.* Employes are forbidden to place newspapers, books, or any other articles in the racks reserved for advertising cards.

41. *Changing Cars on the Road.* In the event of a motorman or conductor being taken sick, or being obliged to leave car for any reason, and in order to keep the road open it is necessary to change ahead, both conductor and motorman of the following car of the same line must take charge of the car ahead. The motorman or conductor of the crew which has been separated must remain at the place where the crews are changing ahead, until an Inspector or another conductor or motorman arrives to complete the crew, and then take the last car which has been left without a crew.

When crews change ahead on the road, the motorman leaving car must notify motorman taking his place of any defect in car equipment which may exist at such time.

42. *Conductor in charge of Car.* The conductor is in charge of car, and the motorman is subject to his orders when they do not conflict with these rules or with special orders.

Should either motorman or conductor show a disposition to run car ahead, or to loaf, the other must make report to proper authority, otherwise he will be held equally responsible.

43. *Electric Heating Apparatus.* Conductors and motormen must not change the position of the switch regulating the electric heaters. If the heat is on or off contrary to orders, this fact must be reported to the first inspector or starter that is met on the road.

44. *Fenders.* A car must never go into or out of a house with fender lowered. Both fenders must be raised and properly strapped to the dash, otherwise they will be likely to strike the side of the door.

When lowering the fender when it is up against the dash, the strap must be unfastened and the fender lowered to the proper position by hand, taking hold of same in center (never at the end or corner), the motorman standing on the ground at the time. If the fender is dropped while motorman is standing on the platform, it is liable to be broken or the intermediates bent.

45. *Watches.* Conductors and motormen must be provided with watches which are in good running order and regulated daily by the Depot clock.

46. *Sand Car.* When a sand car is sent out over a line, sand must be used only on that part of the line where the condition of the rail requires it.

If the crew in charge of a sand car are in doubt about sanding certain portions of the rail they should obtain definite instructions from starters or Inspectors.

47. *Matches.* To lessen danger of fire, no matches shall be kept in lockers.

48. *Leaves of Absence.* Leaves of absence will be granted only on account of illness, or for rest or recreation. No employe will be excused from duty to engage in other occupation or business, nor will his position be held open while so engaged.

49. *Collections.* The collection of money for any purpose, or the solicitation of advertisements for programmes or contributions on behalf of any employe or association of employes, is prohibited.

50. *Assignment of Wages.* Employes are forbidden to give an order on the Company, or assign their wages. They will be paid on the regular pay day, except in cases of dismissal. Those who wish to remain in the service of the Company must pay their lawful debts.

51. *Lost Articles.* Any article left in the car must be turned in at the Division Office at the end of the trip, with the usual form filled out and attached to article in question.

In all cases in which an article is found in the car by a passenger who refuses to turn it over to the conductor, a report containing the name and address of the finder and description of the article must be made to the Division General Foreman.

RULES FOR CONDUCTORS

101. *Be on the Rear Platform.* Remain on rear platform when not collecting fares, keeping a lookout for persons desiring to board car. Keep careful watch of passengers to observe requests to stop car. When stops are made at principal streets, places of amusement, churches, or at any point where a considerable number of passengers enter or leave the car, conductors should be on rear platform until such point is passed.

101*a*. Conductors must remain on running board of open cars, standing opposite the second seat from rear, except when collecting fares.

101*b*. When car is going down a steep or dangerous grade, conductors should remain on rear platform and be ready to set rear brake if necessary.

102.

103.

104. *Route Signs.* See that route signs are properly placed on each half trip.

104*a*. Conductors should see that car is equipped with proper dash signs before leaving depot or terminal.

105. *Carrying Packages.* Passengers must not be allowed to carry bulky or dangerous packages aboard cars.

Do not in any way take possession of, or assume responsibility for, any package which a passenger may bring upon the car, excepting such articles as are to be turned in to the Lost Article Department. Do not hang nor allow articles to be hung on the brake handles.

105*a*. When persons carrying packages present transfer tickets they must be allowed to ride, but the conductor must make a written report of the facts

to his Division General Foreman, the transfer ticket to be attached to said report.

105*b*. Baskets or bundles of soiled clothing will be carried only on the front platforms of cars.

106.

107. *Keeping Gates Closed.* Front and rear gates on closed cars on the side between the tracks must always be kept closed and securely fastened (when running on the road). On open cars the guard rails must be kept down on the side between the tracks. When gates or their fastenings are broken or out of order, prompt report must be made to Division General Foreman, Inspector, or Starter.

108. *Moving Forward.* On closed cars when standing passengers crowd the rear door, request them to PLEASE STEP FORWARD.

109. *Seating Passengers.* Standing passengers should be directed to vacant seats; and an effort made to provide them with seats where possible.

110. *Assisting Passengers.* Elderly and feeble persons, women and children should be given assistance getting on and off car when possible.

111. *Dogs in Cars.* No dogs should be allowed on a car except such small dogs as can be carried in the laps of passengers.

112. *Spitting on Floor.* No passenger will be ejected from a car for spitting on the floor. If a passenger violates the rule or law prohibiting spitting, the conductor will call the attention of the passenger to the law prohibiting such conduct, and endeavor to persuade the passenger to desist.

113. *Collection of Fares.* Fares must be collected promptly after passenger has boarded car and immediately registered. When more than one person boards car at a time, the fares must be registered immediately in the presence of the passenger who paid them before any more fares are collected.

114. *Change.* When necessary to give change, first register fare, and immediately thereafter give change.

114*a*. When starting each trip conductors must have five dollars in change. If bills of five dollars denomination or over are offered in payment of fare, which conductors are unable to change, they must request the passenger to leave the car, but in no case must such a passenger be forcibly ejected for

refusing to comply. The facts in all such cases must be reported to the first Starter or Inspector seen.

114*b*. Conductors must not give more than five pennies to one person making change. Should a passenger object to receiving pennies, conductor must take them back and give other change.

115. *Register Rings.* Be careful to see that register rings each fare and that dial shows it.

116. *Register Out of Order.* In case the register gets out of order, stop using it, make report of fares on back of day card or on blanks supplied for that purpose, and report the fact to the first Inspector, or Starter, met on the road, and subsequently report the same to Division General Foreman.

116*a*. In order to protect themselves from errors in forgetting to register, it is well for conductors to count their money at the beginning of each trip, and at the end of trip to turn in any surplus above what the register calls for, making note of same on back of day cards.

117. *Transfers in Blockades.* In case any line is blocked, it is the desire of the Company to carry passengers to destination on other lines. Under such circumstances, conductors of parallel or intersecting lines will accept transfer tickets accordingly and will issue a transfer on a transfer if necessary. They will also accept transfer passengers without tickets on orders from any Inspectors or authorized representative of the Company making report of same on the back of day card.

117*a*. Conductors on the line which has been blocked must not issue transfer tickets at unusual points unless ordered to do so by an Inspector or other official of the Company.

118. *Refusing to pay Fare. — Transfers.* When a passenger refuses to pay fare or presents a defective transfer or ticket, upon which, in the judgment of the conductor, the passenger is not entitled to ride, the conductor must secure the names of as many witnesses to the facts as is possible, whereupon the car must be stopped and the passenger requested to leave.

If the passenger fails to comply with such request, the facts of the case must be brought to the attention of the first Inspector, Starter or official of the Company who is met, and the conductor must act according to instructions received from such Inspector, Starter or official. In all cases the passenger must be given the benefit of any doubt.

When a passenger who refuses to pay fare requests to be allowed to leave the car, the car must be stopped and the person permitted to alight.

118*a*. *Get Witnesses.* In all cases of ejectment, always get the names of witnesses, and make report giving all the circumstances, the same as in case of accident.

119. *Return of Fare.* Should conductor for any reason return a fare to a passenger, or by error register more fares than collected, he must not attempt to recover same by omitting to register fares subsequently collected. Conductor should report matter at the office, when money will be refunded.

120. *Transportation of Employes.* Employes in uniform with badge displayed, or wearing working clothes (if not soiled) with badge in sight, will be allowed to ride free to and from work upon any of the cars of this Company. Such employes must ride inside of the cars when there is room, but must not occupy a seat while other passengers stand, nor must they converse with men in charge of the car. Not more than two such employes will be allowed to ride on any one car, except during the early morning or late at night when cars are on long headway, and in such event not enough employes to crowd the car will be allowed to board same. Employes of the Engineering Departments wearing soiled clothing will not be allowed on the rear platform or inside of closed cars, but may ride on the front platform thereof, as provided by Rule 36*c*. On open cars such employes may ride only upon the rear platform.

121. *Free Passengers.* Children under four years of age will be carried free when accompanied by an older person.

Police officers and firemen, in uniform, will be carried free, not more than two on any one car. All such officers in addition to two must pay fare.

122. *Information to Passengers.* Conductors are expected to be familiar with principal points along their route, so as to give information to passengers about streets, parks, connecting or intersecting railroad lines, depots, ferries, public buildings, large stores, hotels, theaters, etc.

Conductors on the longitudinal lines must announce distinctly the name of at least every fifth intersecting street and on the crosstown lines the name of every intersecting street. They must call out the names of ferries, theaters, important public buildings and, on arriving at transfer stations, the lines to which transfers are issued.

When on the stand at terminals, and when approaching passengers, conductors must announce the route or destination of car.

Passengers notifying conductor to be let off at some point ahead should be requested to signal conductor just before arriving at the desired street.

123. *Passengers Ring Bell.* Passengers have a right to ring the bell to stop the car, and conductors should bear this in mind. They must, however, try in a polite way to discourage passengers from doing so.

124. *Smoking on Cars.* Smoking or carrying lighted cigars, cigarettes or pipes must not be allowed on any part of box cars, but may be permitted on four rear seats only of open cars, and on open section of combination cars.

125. *Disabled Motorman.* In case any accident disables motorman while the car is in motion, the conductor must at once throw off overhead switch and apply rear brake to stop car.

126. *Care of Cars.* Conductors must make a written report to the Division General Foreman of any cars not in first-class condition for service. Careful

inspection must be made of doors, windows, lamps, and all other parts of car, to see that same are in proper condition.

Conductors must keep papers and rubbish picked up, lights burning after dark, cars properly ventilated and curtains or blinds raised or lowered to give proper shade from sun. At the end of route, where necessary, they must change gates, and run numbers, assist motormen in changing pins, turn seats on open cars, change signs, etc. In general, they must see that cars are in good order, neat and clean. In cold weather, front doors and windows must be kept closed and rear doors also as much as possible.

Care must be taken to regulate ventilators according to number of passengers and condition of the weather, so that the air in car may be kept cool and pure. An endeavor should be made to comply with all reasonable demands from passengers regarding doors, windows, curtains, and ventilators. During cold weather, as a rule, one ventilator at least should be kept open and adjusted so that the opening is toward the rear of the car.

RULES FOR MOTORMEN

201. *Stopping for Passengers.* Keep a careful lookout on both sides of the street and bring the car to a full stop for every person who signals, except that when a car has considerable headway, is overcrowded, and another car follows within the same block (or 200 feet) passengers should be requested to take the following car.

* * * * * * * * * * *

Do not stop cars so as to block cross-streets and crosswalks.

201*a*. Cars will stop on signal only, at farther crossing of street intersections, in front of places of amusement, and in the middle of long blocks.

Cars must stop without signal at all transfer points and at points as provided in special orders.

202. *Churches and Hospitals.* When passing a church during the hours of service, and at all times when passing a hospital, run slowly and do not ring the gong unless necessary.

202*a*. *Passing Schools.* Cars must be run slowly and with great care, and gong sounded, in the vicinity of schools where there are children in the street.

202*b*. *Excavations.* In passing excavations or places where men are working near tracks, gong must be sounded and speed reduced.

203. *Persons between Cars.* Cars moving in opposite directions must not pass at points where persons are standing between the tracks,

but must be operated so as not to occupy both tracks at such point simultaneously.

203*a*. Rule 203 does not apply to the case of police officers detailed at crossings.

203*b*. *Street Sweepers.* In passing laborers at work in the streets, gong must be sounded and car kept under control.

204. *Passing Standing Cars.* When passing standing cars, gong must be rung and car brought to slow speed.

205. *Passing Vehicles.* Motormen are cautioned to exercise great care when a vehicle is passing alongside of track ahead of car. Ring the gong vigorously to attract the attention of the person driving, as a warning not to pull in ahead of car; and run cautiously until the vehicle is passed in safety.

206. *Fire Apparatus.* When any fire department vehicles are observed approaching from any direction, cars must be stopped until such vehicles have passed.

206*a*. The emergency wagons of the Company must always be given the right of way.

207. *Ambulances and Police Patrol.* Ambulances and police patrol must be allowed the right of way, and when approaching or passing, cars must be kept under control to avoid collision.

208. *Passing Cars.* Never run against switch point of crossover when meeting a car, but slacken speed sufficiently to allow the car moving in the opposite direction to pass before striking switch point.

This rule refers particularly to all crossovers having switch points facing opposite to the direction in which the car is moving.

208*a*. *Switches.* Motormen must see that all rail and slot switches are properly set before passing them, coming to a full stop, if necessary. They must run at slow speed over all switches, so that if a switch should be suddenly thrown they can stop car promptly.

209. *Reversing Cars.* Never use the reversing lever to stop car except in a case wherein the brake fails to work properly.

Do not reverse the power when the brake is set, but release the brake and reverse the power simultaneously, and, when the reverse lever is

thrown in position, apply the current one point at a time, otherwise the fuse will melt or the breaker will release. Sand should be used when making an emergency stop.

210. *Leaving Car.* Never leave platform of car without taking controller and reverse handle, throwing off the overhead switch and applying brake. Be careful to see that the hands point to the "off" mark before taking off controller handle. Before leaving car at any point, set hand brake sufficiently to prevent car from drifting.

211. *Throwing Overhead Switches.* An overhead switch must never be thrown until power is turned entirely off, except in case controller cylinder fails to turn when power is on. It must be thrown by hand only.

211*a*. *Repairs.* Before attempting any repairs on car, ground switches must be thrown.

211*b*. *Controller Out of Order.* In case the controller is out of order, and the controller handle cannot be turned to the "off" point, the overhead switch should be thrown.

212. *Power off Line.* When the power leaves the line, the controller must be shut off, the overhead switch thrown, and the car brought to a stop; the light switch must then be turned on and the car started only when the lights burn brightly.

213. *Economical Use of Current.* In order to effect an economical use of the electric current, it is necessary that the continuous movements of starting and increasing speed should be made gradually. In starting a car, let it run until the maximum speed of each notch has been attained before moving handle to the next notch.

Do not apply brakes when the current is on.

Do not apply current when brakes are applied.

Do not allow the current to remain on when car is going down grade, or when passing over section-breakers. Endeavor to run car with the least amount of current, allowing the car to drift without the use of the current when it can be done without falling behind time.

A great amount of power can be saved by using judgment and discretion in approaching stopping places and switches by shutting off the power, so as to allow the car to drift to the stopping place or switch without a too vigorous use of the brake.

214. *Release Brakes before Stop.* When brakes are set to make a stop they should always be released, or nearly so, just before the car comes to a standstill.

215. *Water on Track.* When there is water on the track run the car very slowly, drifting without use of power whenever possible.

216. *Sanded Rails.* Never run on freshly sanded rail with brakes full on except to prevent an accident. On cars provided with sand boxes, in case of slippery rail, always sand the track for a short distance before applying the brakes.

217. *Spinning of Wheels.* Care must be taken, particularly during snowstorms, to avoid spinning of the wheels with no forward or backward movement of the car.

217*a*. When wheels begin spinning, the motorman must shut off power immediately and turn it on again slowly.

218. *Slippery rail.* On a slippery rail do not allow wheels to slide; as soon as wheels commence to slide, the brake must be released and reset.

Extreme caution must be used to keep car under full control approaching all intersections, junctions, railroad crossings and prominent driveways, being very careful when approaching wagons and other cars, disregarding schedule if necessary.

219. *Do Not Oil Car.* Do not oil or grease any part of car.

220. *Rounding Curves.* Power must be shut off and brake applied on approaching all curves, allowing the car to enter the curve on its own momentum with brake partly on. Before movement is lost brake should be released and power applied.

A car must never be stopped on a curve except to avoid accident.

221. *Power Off at Breaks.* At points where there is a break in underground conductor, as indicated by marks on the surface of the street, whether at intersections, curves, or on the straight rail, car must be slowed to one-quarter speed and power be shut off, when the front of car reaches the first mark, and thrown on again when front of car reaches second mark.

222. *Changing Ends.* When changing ends at terminals, motormen must not pass through car.

223. *Place for Oil Coat.* Overcoats and oil coats must not be hung across the front dash, nor on front body of car. They must be either laid on front

platform or neatly folded and hung in hand-rail against body of car on left-hand side.

224. *Terminals.* Motormen must reduce speed when running into terminals to a rate just sufficient to carry car into terminal.

Cars must not be run closer than 20 feet from their leader at terminals. (Exception to the above rule may be made by Division General Foreman.)

225. *No Unauthorized Person to Run Cars.* Motormen must not allow any person to run their cars, except men placed there for instruction, or some Inspector or duly authorized officer of the Company, known to the motorman to be such. Conductors must not be allowed to run cars. Motormen who have on their car and in their charge learners breaking in must, under no circumstances, allow such learners to handle car except when the regular motorman is at his side ready to take the brake or controller in an instant, to prevent accident.

226. *Knowledge of Electrical Equipment.* Motormen are expected to acquaint themselves with the mechanical and electrical equipment of cars, in order that they may be enabled to cut out a motor, replace a fuse, reset a circuit-breaker, or make slight repairs, if necessary.

Motormen should familiarize themselves with the sound made by the car when running, and, if any unusual sound is noticed, should endeavor to find the cause and report it. They should observe carefully whether the car takes its natural speed on all positions of the controller, and, if not, report the fact.

They should apply to proper authority for instructions in any matter that they do not thoroughly understand.

ACCIDENTS

Accidents in which persons are hurt or property destroyed or injured are a serious matter to the motorman and the company, no matter how slight the injury. It is a matter of record that designing persons have been known deliberately to place themselves or their property where it could be injured, for the sake of getting money from the corporation. If a dog is killed by the railroad company it is immediately worth five hundred dollars, though it might have been valued at perhaps five dollars before the accident.

In any accident, the suits growing out of it will certainly cost the company a lot of money, while if the persons are killed or injured the motorman himself may be called upon to defend

a criminal suit. On the other hand, in the case of every accident the company makes a complete investigation, and the motorman who costs them a large sum for a careless accident is pretty sure to get his walking papers and it is perfectly right that he should.

The conductor is responsible for the report to the company and the securing of witnesses, but for his own protection the motorman should see that all the points of importance are put into the report. He should inform the conductor of all that he can in regard to the accident and help him in getting the necessary witnesses.

In case there is any necessity of raising the car to release any one who might be wedged in under it, the motorman should so thoroughly understand the car that he can direct the work and prevent accidents to others who are helping.

Reporting at Car Barn. Get to the car barn a few minutes before starting time so that new notices and instructions can be read.

Inspection of Car. Inspect the car before running it. Look to the brakes, the controllers, the lights, the sanding and the breakers before going out. The time to discover trouble is *before* an accident happens. The shop people may say that a car is all right and they are responsible for it, but in case of accident they are not in danger of their lives and the motorman is. So take a look for yourself.

Starting from Terminus. In starting from an end of the line, always give a gong signal so that the conductor and passengers will not be taken off their balance and injured. See that no one is working under or near the car.

Starting. In starting up do not throw the controller handle

over the first three or four notches suddenly. This is a common trick among motormen and a bad one. The sudden rush of current is almost certain to throw the breaker out and result in a waste of time, and the sudden start of the car often throws passengers who may be standing and who have just cause for damages against the company.

Also sudden starting uses up much more current than careful starting, and wears out the car more quickly besides breaking gears and axles.

Landing Places. Be sure to select a place where persons can get on or off the car without danger of falling into some excavation at the side of the track, or being injured by other obstructions or incumbrances that may be there.

Passing Obstructions. In passing a car on a siding be sure to see that the switch is properly set. Pass slowly so that if any one suddenly leaves the other car and passes in front of you, you will be able to make a quick stop.

Gates and Chains. Platform gates and chains should be kept in the proper position: locked when they should be and open when they should be. When open they should be secured so that they will not swing out of place and cause some one to be caught while passing.

Passing Teams. When passing a team near the track and going in the same direction, always slow down. Horses are liable to slip and fall, and drivers are notoriously careless about crossing the track in front of an approaching car. Do not ring the gong once, but keep doing it till the wagon has been passed. In case of an accident it is not a question of who was right and who wrong, but one of whether it could have been avoided or not by the motorman.

Car Ahead. In running behind another car always do so very slowly, because if you run into it, it will be your fault and no possible excuse will save you. If the brakes are not working or the track is slippery, you should have known all about it before and not waited until you injured the car and passengers.

Wagon Ahead. The same precautions should be observed when a wagon is on the track in front of you as if it were a car. If you hit a wagon you will never hear the end of it.

Crossing Streets. Always signal with the gong when a street crossing is approached.

Conductor's Signals. Never start the car on the first bell. Insist on getting two bells before starting. Very often the conductor rings the bell just as an unseen person attempts to board the car, and starting on the first bell would result in an accident.

Spinning the Brake Handle. Some motormen are in the habit of releasing the ratchet and letting the brake handle spin around. This is a dangerous practice and may result in a broken arm or worse to a passenger standing near, or to the motorman himself. Besides, it is impossible to get hold of the handle before it stops, and if it is necessary to make a quick stop it will be impossible, until the brake handle can be gotten hold of.

Switches. Always approach a switch slowly, and look at it to see that it is properly set. One of the worst accidents that ever happened occurred where a train at full speed took a curve owing to an open switch, when it was expected to keep on the main track.

Curves. Always reduce speed on a curve. The curve is

not safe for high speeds, and it is impossible to see what may be on the track ahead.

In Conclusion. Remember that the motorman is deeply interested in preventing accidents. It is of no consequence whatever how the accident was caused or whose fault it might have been if the motorman could have prevented it. The company is best satisfied by having no accidents whatever, as they cause loss of time and money, no matter who was to blame, and the man who serves his employer best is the man who best serves himself. No man is ever blamed for an accident that he could not have avoided, but the motorman is pretty sure to hear about it if he could have prevented the accident even if he had had the right of way.

NEW YORK AIR BRAKE

Principle of Operation

The "Air Brake" provides means for generating power, and making it effective upon the wheels of each vehicle at practically the same instant of time. It is, in fact, an automatic appliance for quickly and safely stopping a railway train to suit conditions of service both *usual* and *unusual.*

The engineer, by simple movements of a small handle in the cab, operates and has full control of the brakes under all circumstances within his knowledge, but their action is entirely *automatic* and *independent* of the engineer if the train breaks in two, a coupling hose bursts, or a similar accident occurs. On passenger cars, the brake can also be applied by any of the trainmen, if necessary.

The "automatic" action is obtained by providing each vehicle with a supply of compressed air that is always ready for instant use, and by means of which the shoes are forced against the wheels, or withdrawn from them, as desired. This air supply, kept at a pressure of 70 lbs. per sq. in., is

stored in the reservoir upon each car, and in the train pipe connecting them, the apparatus being so constructed that a *reduction of train-pipe pressure* will apply brakes, and an *increase* (restoring what has been used) will release them. Ordinarily, this reduction of train-pipe pressure is made through the engineer's valve, but if air is permitted to escape from the train-pipe *by any cause*, the brakes apply automatically. If the train breaks in two, this automatic action occurs upon *both* sections.

The "quick action" is so called to distinguish its effect from the work which the brake performs in ordinary service. For instance, when stopping the train at stations, or otherwise as required in daily service, the engineer *graduates* the power upon the wheels, thus applying the brakes with whatever force may be necessary, lightly or otherwise; but in an emergency, when life or property is in danger, the *full* brake power is *instantly* at work throughout the train, thus bringing it to a stop in the shortest possible distance.

A Short Description

The air compressed by the compressor is first delivered into the Main Reservoir. From there it flows to the Engineer's Valve, and thence through the Train Pipe to the Triple Valve; passing through the latter into the storage tank or Auxiliary Reservoir upon each car. During normal conditions, the pipes and reservoirs therefore contain compressed air at 70 lbs. pressure. With the Engineer's Valve, changes of Train Pipe pressure are made to operate the Triple Valves on each car, as described below.

Moving the handle of Engineer's Valve a certain distance allows air to escape from the Train Pipe and *reduce* the pressure therein. This reduction of pressure operates the sensitive Triple Valve, which then permits air to flow from the Auxiliary Reservoir into the Brake Cylinder and force the piston of the latter in direction to apply brakes.

To release brakes, the handle of Engineer's Valve is returned to the proper position. This allows air from the Main Reservoir to *again* flow into the Train Pipe, increasing the pressure therein by replacing the air that had escaped. This *increase* of pressure causes the Triple Valve to *reverse* its previous movement and uncover an opening that permits the air

to escape from Brake Cylinder, and thus remove the pressure upon the wheels.

To assist in raising the Train Pipe pressure quickly, and thus insure *prompt* release of the brakes by quick recharging of auxiliary reservoirs, the Main Reservoir air is kept at a pressure of 15 to 20 lbs. *in excess* of the pressure carried in Train Pipe.

Trainmen

1. *Inspection.* In making up trains, all couplings must be united so that the brakes will apply throughout the whole train. The angle cocks at the ends of the cars must be opened, except the one on the rear of the last car, which must be closed. Remember that straight cocks are open when handles are *crosswise* of pipe, and angle cocks are open when handles are *parallel* with pipe.

Trainmen must see that all hand brakes are off before starting.

2. *Testing Brakes.* After making up or adding to a train, or after a change of engines, the rear brakeman must ascertain whether the brake is connected throughout the train. The engineer must then test the brakes to insure of their being properly coupled, and in working order. If the train is provided with the air signal, the signals to apply or release brakes, in testing, should be made from rear end of train, to ascertain if the signal apparatus is in proper order.

3. *Brakes Sticking.* If, after trying the brakes, it is found that one of the triple valves will not release, open the cock or release valve in the auxiliary reservoir until air begins to escape through triple valve port; then close it again. If the brake continues to give trouble, close the stop cock between the train pipe and the triple valve, thus cutting out the brakes on that car, and let air out of the reservoir by opening release valve. When the stop cock is open, the handle is *crosswise* of pipe, and when closed is *parallel* with pipe. Should the brake on the rear car be deranged, cut it out as described, but leave the angle cocks open between the last two cars, and hose connected. Should the train then happen to break in two at this point, the brakes will still be automatically applied before the two sections of the train have parted far enough to cause a serious collision.

4. *At Stations*, where it may be necessary to cut the train to take on, or leave cars, trainmen must not turn the angle cock or disconnect hose until the brakes have been released by the engineer.

When coupling an engine to a train already charged with air, always open angle cock on the engine before turning the one on the car. If the latter is opened first, the sudden rush of air from train line into the empty hose will often cause an emergency application. By turning the cock on the engine first, no application will occur, and the unnecessary waste of air and loss of time to pump it up again is avoided.

5. *Frozen Couplings.* When couplings are frozen together or covered with ice, the ice must first be removed, and then the couplings thawed out, to prevent injury to the gaskets.

6. *Use of Conductor's Valve.* When, in cases of extreme emergency, it becomes necessary to apply the brakes from the cars, the conductor's valve must be kept open until the train is brought to a standstill. The valve must then be closed, otherwise the engineer cannot release the brakes. Accidents have been caused by improper use of the conductor's valve, and *the cases are very rare in which it should be used.*

The old form of conductor's valve was self-closing. The modern form, which has been in use for several years, is a simple plug cock, and must be closed by hand before the brake can be released.

7. *Parting of Train.* In case a train breaks in two, the brakeman should close angle cock on rear car of the section remaining attached to the engine, and then signal the engineer to *release* the brakes. When all the cars are again properly coupled up, but before letting the air into the rear of train, the brakeman should signal the engineer to *apply* brakes, which should be applied hard and left on until the brakeman opens the angle cock into rear section of train. When this is done the engineer will have regained control of the brakes in entire train, as before the break in two, and the necessity for releasing the air from each car, by hand, will thus be avoided.

8. *Burst Hose.* Should the train be stopped by the bursting of a hose, proceed the same as in case of a break in two, and after replacing the broken hose *test brakes carefully on the whole train.*

9. *Hose Couplings.* Dummy couplings or coupling hooks should be

attached at each end of cars, for hanging up the hose when not connected between them. Although opinions differ about the advisability of doing this, we recommend that, until contrary opinion is more unanimous, the practice of hanging up hose be continued.

10. *In Detaching Engines or Cars,* both angle cocks must first be closed, to prevent the application of the brakes, and the couplings then parted by hand.

11. *Hand Brakes* must always be set on cars left at intermediate stations.

12. *Brakes Set on Detached Cars* can be released by opening the cock or release valve on auxiliary reservoir until the air begins to escape through triple valve port; then close the cock again.

13. *Defects.* If any defect is discovered in the brake apparatus, which will affect its working, it must at once be made known to the engineer and all trainmen, in order that the train may be handled accordingly.

14. *Report* to inspectors any car not in good working order.

Inspectors

1. *Inspection.* At terminal stations and division points there should be inspectors to see that air brakes are in good order and in proper adjustment. They should see that all pipes and joints are kept tight, and the rubber gaskets in couplings in good condition; and in passenger yards the inspectors should also examine the conductor's valves, and car discharge valves of the Signal Apparatus, and see that they are kept tight. If desirable, the inspectors may perform the duty assigned to the trainmen.

2. *Care of Brake Cylinders and Triple Valves.* The brake cylinders must always be kept clean, so that the brakes will release promptly when the air has been discharged, and the triple valves kept free from gum and dirt to prevent sticking. They should be examined, cleaned, and oiled about once a year; just how often depends upon the general care given the air-brake equipment, and the special conditions prevailing.

New York freight car equipments have a $\frac{7}{16}$-inch hole drilled in the end of the hollow piston rod or sleeve, where it projects out of the end of the brake cylinder. To take out the piston, put through this hole a $\frac{3}{8}$-inch

bolt, or pin, long enough to extend about half an inch on each side of the sleeve, then ease off the nuts on the back head of the cylinder until the tension of the compressed spring is lessened, and pull out the piston, back cylinder head and spring all together. By using this hole as described, all danger of injury from the compressed spring is avoided, and it is not necessary to carry around horseshoe clamps or any other special devices.

It is a good plan to stencil on cylinder with white paint the following lettering:

Triple cleaned and oiled.....

and opposite these words to mark with chalk the dates of last cleaning and oiling. The above lettering is now cast on all freight car auxiliary reservoirs.

3. *The Adjustment of Brake Gear* should be such that, when the brakes are full on, the pistons will not have moved out over six inches. This will allow for wear of shoes, stretch of rods, etc. When taking up the slack in brake connections, *see that levers and pistons are pushed back to their proper places*, and the slack taken up with the dead levers or *under* connections.

4. *In Cold Weather*, the water which collects in the triple valve should be drained frequently, by removing the plug in the bottom of the valve, which is provided for that purpose.

5. *Repair Parts.* Inspectors must keep on hand for immediate use a supply of all parts liable to get out of repair, as well as tools necessary for making repairs. They should also carry extra triple valves to replace those that may get out of order, and triple valves removed should be sent to the Division Master Mechanic to be repaired.

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